THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 46 SEPTEMBER, 1931 No. 1

PHILIPPINE PINE-NEEDLE OIL FROM PINUS INSULARIS (ENDLICHER)

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TWO PLATES

Benguet pine (*Pinus insularis* Endlicher) forms extensive forests in the mountain regions of northern Luzon. Some months ago we investigated samples of resin tapped from the Benguet pine and our results showed that a turpentine [1] of good quality and a high-grade rosin [2] are obtained from it. Recently we investigated the oil obtained from the leaves (needles) of Benguet pine and found that the yield of oil is very small. The oil appears to consist largely of alpha- and beta-pinene and to contain only a small percentage of esters calculated as bornyl acetate.

Leaf oils are obtained from the leaves of numerous kinds of trees. Oil distilled from the leaves of pine trees is known as pine-needle oil and a number of these oils obtained from dif-

[1] Santos, I. de, A. P. West, and J. Fontanoza, Philip. Journ. Sci. 45 (1931) 233.

[2] Santos, I. de, A. P. West, and J. Fontanoza, loc. cit.

ferent species of pine have been investigated. In general, these oils consist essentially of a mixture of terpenes.

Pine-needle oil has a fragrant odor and is useful in compounding perfumes. It has also been employed as a repellent for certain insects [3] and as a larvicide for mosquitoes.[4]

EXPERIMENTAL PROCEDURE

Through the kindness of Mr. Sixto Laraya, of the Philippine Bureau of Forestry, our laboratory has been supplied during recent months with occasional shipments of pine-needles and twigs. These were gathered from pine trees growing in and near Baguio, a summer resort situated at an elevation of about 1,500 meters in Mountain Province, Luzon.

The pine-needles and twigs were placed in a large apparatus and steam distilled. The pine-needle oil thus obtained was separated from the aqueous distillate and dehydrated with calcium chloride. The yield of oil distilled from leaves and twigs was only 0.043 per cent and subsequent experiments showed that most of the yield was obtained from the leaves and not from the leafless twigs. The oil was slightly greenish yellow in color and had a strong aromatic odor. The constants of the oil were determined and the data are recorded in Table 1.

TABLE 1.—*Constants of pine-needle oil.*

Specific gravity $\left(\frac{30^\circ C}{4^\circ}\right)$	0.8582
Optical rotation $\left(A \frac{30^\circ}{D}\right)$, degrees	+20.53
Refractive index $\left(n \frac{30^\circ}{D}\right)$	1.4700
Acid value	1.38
Saponification value	7.67
Ester value (7.67 — 1.38)	6.29
Esters as bornyl acetate, per cent	1.75

Benguet pine-needle oil was found to be soluble in 10 parts of alcohol (90 per cent). When distilled (fractionated) we obtained the results recorded in Table 2. The first three fractions were practically colorless while the residue had a red color.

[3] Bishop, F. C., R. C. Roark, D. C. Parman, and E. W. Laake, Journ. Econ. Entomol. 18 (1925) 776.

[4] Barnes, M. E., Am. Journ. Hyg. 5 (1925) 309.

TABLE 2.—*Distillation of Benguet pine-needle oil (Amount of oil distilled, 76 cubic centimeters.)*

Fraction.		Amount obtained.		Refractive index, $N\frac{30°C}{D}$.	Specific gravity, $d\frac{30°C}{4°C}$.	Optical rotation, $A\frac{30°C}{D}$ (100 mm. tube).
No.	Temperature.					
	°C.	*Grams.*	*Per cent.*			*Degrees.*
1	Below 155	3.7	4.9			
2	155 to 160	34.4	45.3	1.4645	0.8476	+28.7
3	160 to 164	26.7	35.1	1.4677	0.8493	+18.8
4	Residue	10.8	14.2		0.9420	

In Table 3 are given the boiling points of a few terpene compounds that commonly occur in pine-needle oils.

TABLE 3.—*Boiling points of a few common terpenes.*

Terpene.	Boiling point, ° C.
Alpha-pinene	156–157
Beta-pinene	164–166
Dipentene	170–172
Limonene	172.6–178.2
Borneol	208–213

A comparison of the data given in Tables 2 and 3 indicates that fraction 2 of Benguet pine-needle oil probably contains alpha-pinene and fraction 3 beta-pinene. A sample of fraction 2 was cooled in ice and treated with dry hydrochloric acid gas. There separated out a heavy thick oil that had a strong odor of pinene hydrochloride (artificial camphor). The presence of other substances seemed to prevent the hydrochloride from crystallizing.

A portion of fraction 3 was oxidized with alkaline permanganate. The reaction product was steam distilled and the residue filtered to eliminate manganese oxide. When the filtrate was evaporated somewhat and cooled, white crystals of sodium nopinate separated out. A portion of these crystals was decomposed with dilute sulphuric acid and extracted with benzene. Needles melting at 125.5° to 127° C. were thus obtained, indicating that fraction No. 3 contains beta-pinene.

Due to the very small yield of oil from Benguet pine leaves we did not have sufficient material to make a very thorough investigation of the composition of Benguet pine-needle oil.

In Table 4 are given the constants of pine-needle oils from various species of pine. The figures for specific gravity, refractive index, and optical rotation are not exactly comparable since they were determined at somewhat different temperatures.

As shown by the data (Table 4) pine-needle oils from different species of pine vary considerably in composition. With the exception of *Pinus insularis* and *P. sylvestris*, these oils listed below give a negative rotation. In general, the yield of pine-needle oils is very small. Only one oil (*Pinus pumilis*) gave a yield of more than 0.5 per cent while the other oils gave considerably less.

TABLE 4.—*Constants of pine-needle oils from different species of pine.*

Species.	Yield	Specific gravity.	Optical rotation.	Refractive index.	Acid value.	Esters as bornyl acetate.
	Per cent.					*Per cent.*
Pinus insularis [a]	0.043	0.8582	+20.53	1.4700	1.38	1.75
Abies sibirica [b]	----	0.9000	—30.00	1.4700	1.00	29.00
Do	----	0.9280	—43.00	1.4730	4.00	43.00
Pinus longifolia [b]	----	0.8740	— 6.15	----	1.03	5.00
Pinus pumilio [b]	0.250	0.8630	— 5.00	1.4740	----	3.00
Do	0.750	0.8760	—10.00	1.4800	----	10.00
Pinus sabiniana [b]	0.078	0.8510	—20.00	1.4670	1.47	2.37
Do	0.102	0.8570	—39.00	1.4671	2.05	3.32
Abies magnifica [b]	----	0.8665	—16.70	1.4861	0.75	3.47
Pinus contorta [b]	----	0.8690	—17.84	1.4831	0.90	2.11
Pinus ponderosa [b]	0.040	0.8718	—15.73	1.4789	0.67	1.36
Do	0.126	0.8849	—19.59	1.4838	2.36	2.83
Pinus lambertiana [b]	0.045	0.8676	—11.07	1.4777	0.68	0.74
Do	0.120	0.8738	—16.50	1.4794	2.38	2.07
Pinus halepensis [c]	0.260	0.8960	—49.44	1.4940	----	6.58
Picea vulgaris [d]	----	0.8800	—21.70	----	----	2.90
Do	----	0.8880	—37.00	----	----	3.43
Pinus sylvestris [e]	----	0.8661	+13.20	1.4729	0.28	----
Pinus excelsa [f]	0.310	0.8672	—13.76	1.4727	1.00	3.75

[a] *Pinus insularis* from the Philippines.
[b] Parry, E. J., Chemistry Essential Oils and Perfumes 1 (1918) 51.
[c] Rutovskii, B. N., Perfum. Essen. Oils. Rec. 19 (1928) 391.
[d] Allen's Commercial Organic Analysis 4 (1925) 112.
[e] Rao, B. S., and J. L. Simonsen, Journ. Chem. Soc. 127 (1925) 2494.
[f] Rutovskii, B., I. Vinogradova, and V. Koslov., Arbeiten Chem. Pharm. Inst. Moskaus, Lief 11 (1925) 93.

The authors wish to thank Mr. Arthur F. Fischer, director, Philippine Bureau of Forestry, and Mr. Luis J. Reyes, chief, division of forest products, Bureau of Forestry, for their cooperation and assistance in this work.

The authors also wish to thank Mr. Sixto Laraya, of the Philippine Bureau of Forestry, for his kindness in procuring samples of Benguet pine needles for this investigation.

SUMMARY

We have investigated the pine-needle oil obtained from Benguet pine (*Pinus insularis* Endl.).

Benguet pine-needle oil has a positive optical rotation and in this respect is unlike most pine-needle oils which have a negative rotation.

Compared to other pine-needle oils, the yield from Benguet pine leaves is very small (0.043 per cent).

Benguet pine-needle oil appears to consist largely of alpha- and beta-pinene and to contain only a small percentage of esters calculated as bornyl acetate. It is soluble in ten parts of 90 per cent alcohol.

ILLUSTRATIONS

PLATES 1 and 2. Philippine pine trees in Baguio. 7

PLATE 1.

PLATE 2.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM THE PHILIPPINES (DIPTERA), X[1]

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THREE PLATES

The important series of Philippine crane flies discussed at this time were collected in Luzon by Messrs. McGregor, Duyag, and Rivera, and in Mindanao by Mr. Charles F. Clagg. I wish to thank the above-mentioned gentlemen for their continued interest in making known the tremendously rich tipulid fauna of the Philippines. All types are preserved in my collection.

TIPULINÆ

SCAMBONEURA NIGROTERGATA sp. nov. Plate 2, fig. 23.

General coloration obscure yellow; antennæ (male) elongate, the scapal segments yellow; mesonotal præscutum with three narrow, ill-delimited, reddish brown lines; postnotal mediotergite and pleura yellow, unmarked; wings subhyaline; anterior arculus bowed; abdominal tergites with a continuous black dorsomedian stripe from base to apex; sternites light yellow; male hypopygium with the tergite uniformly blackened; appendage of ninth sternite small, bilobed.

Male.—Length, about 13 millimeters; wing, 11.3; antenna, about 7.

Frontal prolongation of head obscure yellow; nasus black; palpi light brown, the outer segment passing into black. Antennæ (male) elongate, as shown by the measurements; scape obscure yellow; flagellum black, the segments elongate, their longest verticils about one-fourth to one-fifth the segment. Head obscure orange, with a brown median line on vertex; additional narrower and less-defined dark lines on vertex, delimiting the posterior vertex.

Pronotum obscure yellow. Mesonotal præscutum obscure yellow, with three narrow reddish brown stripes that are ill-de-

[1] Contribution from the entomological laboratory, Massachusetts Agricultural College.

limited; scutum yellowish testaceous, the cephalic half of the lobes blackened; scutellum testaceous; postnotal mediotergite yellow, unmarked. Pleura yellow. Halteres brownish black, the knobs black. Legs with the coxæ and trochanters yellow; femora brownish black, their bases broadly yellow; tibiæ and tarsi black. Wings subhyaline, iridescent, the stigmal region dark brown; veins black. Venation: Anterior cord strongly bowed; m-cu nearly half its length beyond the fork of M.

Abdomen with the tergites pale, with a continuous dull black median stripe the entire length, more extensive and somewhat paler on outer segments; a narrower continuous lateral black line; sternites clear light yellow; hypopygium yellow, the tergite entirely black. Male hypopygium (Plate 2, fig. 23) with the tergite, 9*t*, bearing two conspicuous earlike lobes, separated by a V-shaped median notch that further bears a tiny median tonguelike projection; mesal margin of lobes with delicate setulæ at apex, these replaced by coarse black setæ that merge gradually into short black spines on the face of the lobes. Outer dististyle, *od*, obliquely broadest beyond base, the outline irregular, the outer edge most protuberant just beyond base, the inner margin more strongly rounded at near midlength. Appendage of ninth sternite, 9*s*, small, conspicuously bilobed, the entire surface setiferous.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 5, 1930 (*Clagg*); holotype, male.

This species and the next are very different from the other known species of *Scamboneura*, although closely allied to one another. The nearest ally in Luzon would seem to be *S. vittivertex* Alexander.

SCAMBONEURA CALIANENSIS sp. nov. Plate 2, figs. 24 and 25.

Male.—Length, about 15 millimeters; wing, 14.2; antenna, about 6.

Generally similar to *S. nigrotergata* sp. nov.; in the general coloration, differing as follows:

Size larger, but the antennæ (male) proportionately and actually shorter, as shown by the measurements, the flagellar segments being conspicuously shorter. Scutal lobes with the markings reddish brown and occupying the whole lobe. Pleura yellow, vaguely marked with more reddish yellow on the anepisternum and ventral sternopleurite. Abdomen with the dorsomedian black stripe not quite continuous, being narrowly

interrupted at the caudal margins of the segments. Male hypopygium with the tergite (Plate 2, fig. 24, 9*t*) entirely blackened and shaped generally as in *nigrotergata* but the details quite different. Lateral ears conspicuous, with abundant long coarse setæ but no replacement spines on disk; median projection large and conspicuous. Outer dististyle (Plate 2, fig. 25) long and conspicuous, the apex produced into a slender point.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 4, 1930 (*Clagg*); holotype, male.

LIMONIINÆ

LIMONIINI

LIMONIA (LIMONIA) CANDIDELLA sp. nov. Plate 1, fig. 1; Plate 2, fig. 26.

General coloration yellow, the præscutum with a brown median stripe; antennæ black, the flagellar segments cordate, with glabrous apical necks; legs black, all tarsi with intermediate portions white; wings with a strong blackish suffusion; male hypopygium with the basistyles elongate, the ventromesal lobe small, at extreme base.

Male.—Length, about 6 millimeters; wing, 6.8.

Rostrum and palpi black. Antennæ black throughout; intermediate flagellar segments cordate, with glabrous apical necks that are about one-third the length of the segment; outer segments more elongate; terminal segment long, about one-half longer than the penultimate; verticils shorter than the segments. Head black, the front silvery; anterior vertex relatively wide.

Pronotum dark medially, obscure yellow on sides. Mesonotal præscutum clear yellow, with a narrow median brown stripe, the usual lateral stripes ill-delimited, brownish yellow, the humeral region brightest; scutum yellow, the centers of the lobes vaguely darker; scutellum brown, obscurely brightened posteriorly; postnotum brownish yellow. Pleura light yellow, the dorsal sclerites a little more darkened. Halteres black. Legs with the coxæ and trochanters pale yellow, the fore coxæ a trifle more darkened; femora brownish black, the bases restrictedly brightened; tibiæ dark brown; tarsi dark brown, the intermediate portion of all tarsi snowy white, this involving the distal third or more of basitarsi, the entire second segment and all but the tip of the third segment; the amount of white greatest on the hind legs where the distal two-thirds of the basitarsus is included; claws small, with a single basal tooth. Wings (Plate 1, fig. 1) with a strong black suffusion, the small oval stigma

darker; extreme wing tip vaguely darkened; veins brownish black. Costal fringe of moderate length. Venation: Sc long, Sc_1 ending beyond the fork of Rs, Sc_2 a short distance from its tip; free tip of Sc_2 and R_2 in alignment; Rs less than twice the basal section of R_{4+5}; cell 1st M_2 closed, shorter than any of the veins beyond it; m-cu just beyond the fork of M; vein 2d A long, converging strongly toward 1st A.

Abdominal tergites black; basal sternites obscure yellow; outer sternites and hypopygium darker. Male hypopygium (Plate 2, fig. 26) much as in *L. multinodulosa* in the median extension of the tergite, elongate basistyles, *b*, with the ventromesal lobe small and situated at the extreme base, and the general conformation of the dististyles and gonapophyses. The dorsal dististyle, *dd*, is a more strongly curved hook.

LUZON, Laguna Province, above Ube, foot of Mount Banahao, altitude about 700 meters, on mossy cliff near river in cool forest, February 9, 1930 (*McGregor*); holotype, male.

Limonia (*Limonia*) *candidella* is most closely allied to *L.* (*L.*) *multinodulosa* Alexander (Luzon), differing in the much shorter antennæ of the male and the white intermediate tarsal segments of all the legs. The increased length of the antennæ in *multinodulosa* is produced by the longer glabrous apical necks of the segments.

LIMONIA (LIMONIA) LATIFLAVA sp. nov. Plate 1, fig. 2.

General coloration brownish yellow, the posterior sclerites of the mesonotum blackened; antennæ black; pleura yellow with a black longitudinal stripe; halteres black; legs black, the tarsi and broad tibial tips yellowish white; wings with a blackish tinge, the basal cells streaked with whitish; Sc long, Sc_2 at tip of Sc_1.

Female.—Length, about 5 millimeters; wing, 5.

Rostrum black, relatively long and conspicuous, about one-half as long as the remainder of head; palpi black. Antennæ black throughout; flagellar segments oval. Head black, sparsely pruinose; anterior vertex narrow, lighter gray.

Pronotum black. Mesonotal præscutum obscure brownish yellow, paler laterally, more brownish medially; posterior sclerites of mesonotum more uniformly brownish black. Pleura with a conspicuous longitudinal black stripe extending from the pronotum to the abdomen, the dorsopleural region obscure yellow; ventral pleural region clear light yellow. Halteres black. Legs

with the coxæ and trochanters light yellow; femora black, their bases restrictedly pale; tibiæ black, the tips paling to yellowish white, this subequal in amount on all legs and including about the distal fourth or fifth; tarsi similarly yellowish white. Wings (Plate 1, fig. 2) with a strong blackish suffusion, the oval stigma darker; conspicuous whitish streaks in the proximal ends of cells R, M, Cu, and both anals; veins brownish black. Venation: Sc long, Sc_1 ending shortly before the fork of Rs, Sc_2 at its tip; Rs long, arcuated; free tip of Sc_2 and R_2 in transverse alignment; m-cu just beyond the fork of M; vein 2d A converging toward 1st A at base.

Abdominal tergites brownish black, the sternites yellow. Ovipositor with the tergal valves relatively small, strongly upcurved; sternal valves straight, their bases blackened.

LUZON, Laguna Province, above Ube, February, 1930 (*McGregor*); holotype, female.

Limonia (*Limonia*) *latiflava* is very different from other regional species of the subgenus, the most distinctive characters being the very extensive pale apices of all the legs, the coloration involving not only the entire tarsi but also the tips of the tibiæ.

LIMONIA (LIMONIA) FLAVOHUMERALIS sp. nov. Plate 1, fig. 3; Plate 2, fig. 27.

General coloration black, the humeral and lateral regions of the præscutum broadly and conspicuously light yellow; pleura with a broad black longitudinal stripe; wings dark gray, the margins still darker; Sc long, Sc_2 at tip of Sc_1; male hypopygium with the ventral dististyle small, the rostral prolongation long, without spines.

Male.—Length, about 3.5 millimeters; wing, 4.2.

Rostrum and palpi black. Antennæ black; flagellar segments oval, passing into more elongate-oval; terminal segment elongate, about one-half longer than the penultimate, the distal end pointed; verticils short. Head large, especially the eyes; dorsum dark gray, the anterior vertex reduced to a capillary strip.

Pronotum black, the posterior notum yellow. Mesonotal præscutum light yellow, including the very broad humeral and lateral portions; a triangular brownish black median shield on posterior half, this sending a scarcely apparent vitta cephalad to the margin; scutal lobes blackened, the median area testaceous, the lateral margins yellow; scutellum brownish black; postnotal mediotergite testaceous brown. Pleura with the dorsal

portion occupied by a broad black longitudinal stripe that extends from the pronotum to the abdomen, encircling the root of the halteres; sternopleurite and meral region pale yellow; dorsopleural region adjoining the wing root obscure yellow. Halteres infuscated. Legs with the fore coxæ darkened, the other coxæ and all trochanters yellow; femora dark brown, the bases narrowly obscure yellow; remainder of legs brownish black, the tarsi very insensibly paler; claws nearly simple. Wings (Plate 1, fig. 3) with the disk dark gray, the margins more infuscated; stigma subcircular, darker brown; conspicuous dusky seams along vein Cu in cell M, along Rs and the cord; veins brownish black. Costal fringe short; macrotrichia of veins long and conspicuous. Venation: Sc long, Sc_1 ending about opposite two-thirds the length of Rs, Sc_2 at its tip; cell 1st M_2 closed, relatively short; m-cu close to fork of M; cell 2d A narrow, the veins gently converging near origin.

Abdomen brownish black; hypopygium dark. Male hypopygium (Plate 2, fig. 27) with the tergite, 9*t*, transverse, the caudal margin convexly rounded, with a deep and narrow median incision. Basistyle, *b*, relatively large, especially the large, obtuse, ventromesal lobe. Dorsal dististyle a short, stout, flattened blade, the apex suddenly narrowed to an acute point. Ventral dististyle small, oval, much smaller than the basistyle, the body of the style with long coarse setæ; rostral prolongation long and slender, without rostral spines. Gonapophyses, *g*, with the mesal-apical angle a stout lobe.

LUZON, Laguna Province, above Ube, at foot of Mount Banahao, altitude about 700 meters, in cool forest, February 9, 1930 (*McGregor*); holotype male.

Limonia (*Limonia*) *flavohumeralis* is most similar in general coloration to *L.* (*L.*) *retrusa* Alexander (Luzon), differing very notably in all details of coloration and structure of the male hypopygium.

LIMONIA (LIMONIA) CANIS sp. nov. Plate 1, fig. 4; Plate 2, fig. 28.

Allied to *L. cynotis;* general coloration dark brown; wings with a strong blackish tinge, without stigmal darkening; free tip of Sc_2 far before R_2; male hypopygium with the ventromesal lobe of basistyle long and slender; dististyle single, shaped more or less like a dog's ear, the mesal face on apical half with spinous setæ.

Male.—Length about 4 millimeters; wing, 4.6.

Rostrum and palpi dark brown. Antennæ black throughout; basal flagellar segments subglobular, passing to oval outwardly; terminal segment scarcely longer than the penultimate; segments densely clothed with microscopic black setulæ and a few stout verticils of moderate length. Head dull black.

Mesonotum chiefly brownish black, the pleura paler, more obscure testaceous. Halteres infuscated. Legs with the coxæ and trochanters testaceous yellow; remainder of legs dark brown. Wings (Plate 1, fig. 4) with a strong blackish suffusion, without a stigmal darkening; veins darker brown. Venation: Sc long, Sc_1 ending at about two-thirds to three-fourths the length of the nearly straight Rs, Sc_2 at its tip; free tip of Sc_1 far before level of R_1; m-cu close to fork of M; anal veins nearly parallel to very weakly convergent at origin.

Abdomen brownish black. Male hypopygium (Plate 2, fig. 25) generally as in *L. cynotis* in the conformation of the styli, differing conspicuously in details. Tergite, 9t, large, narrowed outwardly, the caudal margin with a broad U-shaped emargination. Basistyle, *b*, with the ventromesal lobe very long and slender, only a little shorter than the dististyle, narrowed outwardly. Dististyle, *d*, single, shaped more or less like a dog's ear, the spinous setæ on mesal face restricted to distal half. Gonapophyses, *g*, pale, the mesal-apical lobe slender, the tip produced slightly laterad into a point.

Luzon, Laguna Province, above Ube, at foot of Mount Banahao, altitude about 700 meters, near river in cool forest, February 9, 1930 (*McGregor*); holotype, male.

Limonia (*Limonia*) *canis* is allied to *L.* (*L.*) *cynotis* Alexander (Mindanao), differing most evidently in the structure of the male hypopygium, especially the long ventromesal lobe of the basistyle and the vestiture of the dististyle.

LIMONIA (RHIPIDIA) MORIONELLA (Edwards).

Rhipidia (*Rhipidia*) *morionella* Edwards, Journ. Fed. Malay States Mus. 14 (1928) 70.

Luzon, Mountain Province, Benguet, Mount Santo Tomas, altitude over 5,000 feet, March 21 to 24, 1930 (*Rivera*); Tayabas Province, Candelaria, June 25, 1930 (*McGregor and Rivera*).

These agree exactly with the types from the Federated Malay States except that the second tarsal segment is darkened.

LIMONIA (RHIPIDIA) LUTEIPLEURALIS sp. nov. Plate 1, fig. 5.

Belongs to the *rostrifera* group; closely allied to *L. morionella;* general coloration black, the thoracic pleura yellow, only the ventral sternopleurite darkened; wings unmarked except for stigma; terminal tarsal segments whitish.

Male.—Length, about 3.5 to 3.8 millimeters; wing, 4 to 4.4.

Female.—Length, about 4 millimeters; wing, 3.8 to 4.

Closely allied to *L. morionella;* differing especially in the yellowish thoracic pleura.

Rostrum longer than the remainder of head, black. Antennæ black, the apices of the axial portions of the segments paler; antennæ of male long-bipectinate; of female, simple. Head black.

Mesonotum brownish black, the pleura obscure yellow, only the ventral sternopleurite darkened. Halteres dusky, the base of stem restrictedly pale. Legs with the coxæ and trochanters yellow; remainder of legs black, the femoral bases restrictedly brightened; subterminal tarsal segments restrictedly whitish, more extensive and clearer white on posterior legs where from one-fourth to one-third of the tarsus is this color. Wings (Plate 1, fig. 5) whitish hyaline, unmarked except for the conspicuous short-oval brown stigma; veins brownish black. Venation: Sc_1 ending about opposite one-third the length of Rs, Sc_2 far from its tip, Sc_1 alone being one-half longer than Rs; cell M_2 open by the atrophy of m; cell 2d A wide.

Abdominal tergites dark brown, the sternites more yellow. Male hypopygium dark brown. Ovipositor with the genital shield blackened, the valves paling to horn-color.

LUZON, Mountain Province, Benguet, Mount Santo Tomas, altitude over 5,000 feet, March 21 to 25, 1930 (*Rivera*); holotype, male; allotype, female; paratypes, numerous males and females.

Although closely allied to *L.* (*R.*) *morionella* (Edwards), I must consider the present fly to be distinct by reason of the yellow thoracic pleura. The amount of white on the tarsi is more restricted and obscured in the present species. It should be observed that following the inclusion of *Rhipidia* as a subgenus of *Limonia* (*Limnobia*), *morionella* Edwards (1928) becomes preoccupied by *morionella* Schiner (1868) and should be renamed. The members of the *rostrifera* group do not seem to be strictly consubgeneric with *Rhipidia* but rather to represent a distinct off-shoot of the genus.

LIMONIA (GERANOMYIA) PHŒNOSOMA sp. nov. Plate 1, fig. 6; Plate 2, fig. 29.

General coloration reddish; head blackish gray with a silvery median vitta; postnotal mediotergite dark brown; knobs of halteres blackened; wings with a faint brown tinge, sparsely marked with small brown clouds that are distributed in the costal field; male hypopygium with the cephalic margin of the rostral prolongation of ventral dististyle with sclerotized bracing areas; rostral spines very elongate; gonapophyses with apices of mesal-apical lobes bifid.

Male.—Length, excluding rostrum, about 5.5 millimeters; wing, 5.6; rostrum, about 2.2 to 2.3.

Female.—Length, excluding rostrum, about 5.5 to 7 millimeters; wing, 5.5 to 6.3; rostrum, about 2.4 to 2.8.

Rostrum and palpi black, the former of moderate length only, slightly longer in the female. Antennæ black throughout; flagellar segments oval to subcylindrical, the verticils short and inconspicuous. Front and anterior vertex silvery; remainder of head blackish gray, with a silvery median vitta to the occiput; anterior vertex narrow.

Mesonotum shiny reddish yellow, the disk of the præscutum and the scutal lobes darker, more chestnut-red, the lateral portions more yellowish; scutellum obscure yellow, darker basally; postnotal mediotergite conspicuously dark brown, the lateral portions yellow. Pleura reddish yellow. Halteres pale, the knobs infuscated. Legs with the coxæ and trochanters yellow; femora obscure yellow, more brownish on distal half; tibiæ and tarsi brownish yellow, the terminal segments darkened; claws with a powerful basal tooth, with an additional microscopic denticle more proximad. Wings (Plate 1, fig. 6) with a faint brown tinge, sparsely patterned with brown, including the stigma and small spots at origin of Rs, fork of Sc, along anterior cord, and as a marginal seam in the radial field; narrow and less conspicuous seams to the supernumerary crossvein in cell Sc, along posterior cord, and on outer end of cell 1st M_2; veins brownish black. Costal fringe short. Venation: Sc long, Sc_1 ending at near four-fifths the length of Rs, Sc_2 at its tip; a supernumerary crossvein in cell Sc at about two-thirds the length of vein R; Rs weakly angulated at origin; cell 1st M_2 closed; m-cu at or before the fork of M; cell 2d A narrow, the anal veins at base generally parallel.

Abdominal tergites brownish black, the basal segments a little brightened laterally at the incisures; sternites yellow; outer segments of abdomen paler in both sexes. Male hypopygium (Plate 2, fig. 29) with the tergite, 9*t*, transverse, the caudal margin convexly rounded, divided by a small median notch into two halves that are provided with abundant setæ. Basistyle, *b*, relatively small, the ventromesal lobe large, conspicuously setiferous. Dorsal dististyle a very strongly curved chitinized sickle, the acute tip blackened. Ventral dististyle, *vd*, fleshy, oblique, the conspicuous rostral prolongation protected along its cephalic margin by sclerotized areas; two very long, curved, rostral spines, arising from a common basal tubercle, placed near apex of the prolongation. Gonapophyses, *g*, with the mesal-apical lobes conspicuously bifid at apex.

LUZON, Laguna Province, above Ube, February 6 to 12, 1930 (*McGregor and Rivera*); holotype, male; allotype, female; paratype, female; Tayabas Province, Candelaria, June 25, 1930 (*McGregor and Rivera*); paratype, female.

Limonia (*Geranomyia*) *phœnosoma* is readily told by the peculiar structure of the male hypopygium.

LIMONIA (GERANOMYIA) LONGIFIMBRIATA sp. nov. Plate 1, fig. 7; Plate 2, fig. 30.

General coloration yellow; mesonotal præscutum with three gray stripes that are separated by two narrow blackish lines; halteres dusky; wings with a faint brownish tinge, very sparsely patterned with brown; costal fringe (male) very long and conspicuous; cell M_2 open by the atrophy of m; male hypopygium with the ventral dististyle large and fleshy; spines of the rostral prolongation from long basal tubercles that are widely separated; mesal-apical lobe of gonapophyses very long and slender.

Male.—Length, excluding rostrum, about 6 millimeters; wing, 6 to 6.2; rostrum, about 2.5.

Female.—Length, excluding rostrum, about 5 millimeters; wing, 6.2; rostrum, about 2.

Rostrum and palpi black. Antennæ black throughout; flagellar segments cylindrical with short inconspicuous verticils. Head blackish gray; a narrow silvery line from the front to the occiput.

Pronotum blackish gray. Mesonotal præscutum with three gray stripes, the interspaces dull black, the humeral and lateral regions obscure yellow; scutum obscure yellow, the lobes extensively blackish gray; scutellum testaceous; postnotal medioter-

gite dark brown, especially on the posterior half. Pleura obscure yellow, the pleurotergite a trifle darkened. Halteres dusky. Legs with the coxæ and trochanters pale greenish yellow; remainder of legs dark brown, the femoral bases restrictedly brightened; basal tarsal segments paling to brownish yellow. Wings (Plate 1, fig. 7) with a faint brown tinge; stigma oval, dark brown; a vague gray clouding along cord; wing apex in radial field narrowly bordered by brown; veins dark brown. Costal fringe (male) very long and conspicuous. Venation: Sc long, Sc_1 ending about opposite or beyond midlength of Rs, Sc_2 at its tip; a supernumerary crossvein in cell Sc; cell M_2 open by the atrophy of m; m-cu at or close to the fork of M.

Abdominal tergites dark brown, the sternites greenish yellow. Male hypopygium (Plate 2, fig. 30) with the caudal margin of tergite gently emarginate, with two low lobes. Basistyle, *b*, relatively small, the ventromesal lobe moderately large. Ventral dististyle, *vd*, a very large fleshy lobe, the rostral prolongation large, complex in structure, the two spines arising from widely separated pale tubercles, the inner spine shorter. Dorsal dististyle a strongly curved pale sickle, the tips slightly upcurved. Gonapophyses, *g*, with the mesal-apical lobe very long and slender, gently curved.

LUZON, Laguna Province, Mount Maquiling, May 23 to 30, 1930 (*Duyag*); holotype, male; paratype, male; above Ube, altitude 400 meters, January 27, 1930 (*McGregor*), paratype, male; Pampanga Province, Mount Arayat, October, 1929 (*Rivera*); allotype, female.

Limonia (*Geranomyia*) *longifimbriata* is very distinct from regional species in the unusually long costal fringe in the male and the open cell M_2.

LIMONIA (GERANOMYIA) PARAMANCA sp. nov. Plate 1, fig. 8.

Belongs to the *argentifera* group; allied to *L. manca* in the open cell M_2; wings with a strong dusky tinge, the stigma and a broad marginal seam in cell R_2 darker brown.

Female.—Length, excluding rostrum, about 4.8 millimeters; wing, 4.5; rostrum, about 2.5.

Rostrum long, black; palpi black. Antennæ black throughout, the verticils short. Head gray, the front and anterior vertex silvery; central portion of posterior vertex extensively blackened.

Mesonotum polished black, the præscutum with a silvery area on sides behind pseudosutural foveæ, with a smaller similar

sublateral area at suture; scutellum and postnotum more pruinose. Pleura heavily silvery pruinose, the sternal region paler. Halteres yellow. Legs with the coxæ and trochanters yellow; femora obscure yellow, slightly darker beyond base; remainder of legs brown. Wings (Plate 1, fig. 8) with a strong dusky tinge, the stigma and a broad marginal seam in cell R_2 darker brown; veins brownish black. Costal fringe relatively long and conspicuous for the female sex. Venation: Sc_1 ending beyond midlength of Rs; an unusually wide supernumerary crossvein in cell Sc at near two-thirds the length of vein R; cell M_2 open by the atrophy of m; m-cu about one-half its length beyond the fork of M, the distal section of Cu_1 very short; cell 2d A narrow.

Abdominal tergites black, the sternites paler, more brownish; genital segment brownish yellow. Ovipositor with the tergal valves very slender, gently upcurved, reddish horn color.

LUZON, Tayabas Province, Candelaria, June 25, 1930 (*McGregor and Rivera*); holotype, female.

Limonia (*Geranomyia*) *paramanca* is readily distinguished from the other members of the *argentifera* group by the darkened wings, in conjunction with the small size and open cell M_2. The other members of the group, with the exception of *manca* Alexander (North Queensland) have cell 1st M_2 closed (*argentifera* de Meijere, *nigronotata* Brunetti, *nigronitida* Alexander, and *pleuropalloris* Alexander). As I have indicated in another paper, a study of the type specimen of *sorbillans* (Wiedemann) shows that it, too, belongs to this group and is very probably identical with *argentifera*. The type is a female, in relatively poor condition, and the synonymy cannot be readily affirmed.

LIMONIA (PSEUDOGLOCHINA) ANGUSTAPICALIS sp. nov. Plate 1, fig. 9; Plate 2, fig. 31.

General coloration dark brown, the pronotum and broad pleural region yellow; fore femora white, the tips narrowly blackened; posterior femora dark brown; remainder of legs snowy white, all tibiæ with a single narrow black ring at midlength; wings whitish, the large stigma and narrow apex blackened; abdominal sternites distinctly bicolored; male hypopygium with a single stout rostral spine.

Male.—Length, about 5 millimeters; wing, 5.5.

Female.—Length, about 5 millimeters; wing, 5.

Rostrum pale yellow; palpi black. Antennæ black throughout, relatively elongate, the long-oval segments with short apical pedicels. Head yellow, more dusky on the orbits.

Pronotum light yellow. Mesonotum dark brown, with a more or less distinct paler median line from the posterior portion of the præscutum to the postnotal mediotergite where it becomes more pruinose. Pleura chiefly occupied by a broad yellow longitudinal stripe, more pruinose on its ventral portion; dorsal pleurotergite and ventral sternopleurite dark brown. Halteres pale, the knobs infuscated. Legs with the coxæ and trochanters brownish yellow; fore femora white, the tips narrowly blackened; posterior femora dark brown, the tips narrowly blackened; all tibiæ snowy white with a single narrow black ring at midlength; tarsi snowy white. Wings (Plate 1, fig. 9) whitish, the apex in outer radial cells darkened; stigma large, dark brown; veins black, the prearcular veins R whitish. Venation: Sc_1 ending just beyond the fork of the short oblique Rs; cell 2d M_2 deep; m-cu at fork of M; cell 2d A small, as in *L. unicinctipes*.

Abdominal tergites dark brown, the intermediate segments with a paler brown subterminal area; subterminal segments blackened; sternites bicolored, the bases broadly black, the tips about equally yellowish white; ventral dististyle pale yellow. Male hypopygium (Plate 2, fig. 31) with the ventral dististyle, *vd*, large and fleshy, the rostral prolongation small, with a single short powerful spine. Gonapophyses broad-based, the mesal-apical angle small.

LUZON, Laguna Province, Mount Maquiling (*Duyag*); holotype, male; allotype, female, January 28, 1930; paratype, male, May 23 to 30, 1930 (*Duyag*).

Limonia (*Pseudoglochina*) *angustapicalis* is most closely allied to *L.* (*P*). *unicinctipes* Alexander, differing most conspicuously in the large stigmal area, distinctly darkened apex of the wings, and the dimidiate abdominal sternites.

LIMONIA (ALEXANDRIARIA) SOLLICITA sp. nov. Plate 1, fig. 10.

General coloration gray; antennæ black throughout; knobs of halteres dark brown; legs yellow, the terminal three tarsal segments dark brown; wings gray, sparsely patterned with brown; Sc short, Sc_1 very long; a marginal spur of vein M_3 persisting.

Female.—Length, about 5 millimeters; wing, 5.

Rostrum black, the labial palpi brown, the maxillary palpi black. Antennæ black throughout; flagellar segments oval, more elongate outwardly, the terminal segment a little longer than the penultimate. Head gray; anterior vertex narrow.

Pronotum and mesonotum brown, the three præscutal stripes darker brown but almost concealed by yellowish pollen; scutal

lobes brownish black, the median area paler; scutellum brownish gray; postnotum dark gray. Pleura gray. Halteres short, obscure yellow, the knobs dark brown. Legs with the coxæ brownish yellow, the fore coxæ somewhat darker; trochanters yellow; remainder of legs yellow, the three terminal tarsal segments infuscated; third and fourth tarsal segments on flexor surface with rows of evenly spaced pale spines on the entire length of the segment; claws small, with a single well-developed tooth. Wings (Plate 1, fig. 10) gray, sparsely patterned with brown; stigma oval, brown; restricted grayish brown clouds at Sc_2, origin of Rs, and along cord; veins dark brown. Venation: Sc short, Sc_1 ending opposite the origin of Rs, very long, Sc_2 being at near midlength of R; a marginal spur of M_3 back from wing edge; m-cu close to fork of M; cell 2d A wide.

Abdominal tergites dark brown, the sternites brownish yellow. Ovipositor with the tergal valves very slender, the sternal valves correspondingly stout and deep.

LUZON, Laguna Province, Ube, December, 1929 (*Rivera*); holotype, female.

Limonia (*Alexandriaria*) *sollicita* is very different from the other regional species of the subgenus. The wing pattern is almost as in *L.* (*Dicranomyia*) *sordida* (Brunetti) and similar species. It is uncertain as to how constant the presence of the marginal vein M_3 will prove to be.

ORIMARGA (ORIMARGA) RUBRICOLOR sp. nov. Plate 1, fig. 11.

General coloration red; antennæ black throughout; wings milky gray, the veins pale; macrotrichia of veins relatively sparse, there being only about four on the distal half of R_3.

Male.—Length, about 3.2 millimeters; wing, 3.8.

Female.—Length, about 3.6 millimeters; wing, 3.8.

Rostrum and palpi black. Antennæ black throughout; flagellar segments subglobular, passing into oval outwardly. Head gray.

Thoracic dorsum reddish brown, the pleura clearer red. Halteres pale. Legs with the coxæ reddish; trochanters testaceous; remainder of legs pale brown, long and slender. Wings (Plate 1, fig. 11) milky gray, the prearcular and costal regions light yellow; veins pale. Costal fringe relatively long and conspicuous. Macrotrichia of veins relatively sparse, there being four on distal half of R_3, widely separated; a series of about twenty to twenty-five the entire length of the distal section of R_{4+5}, more crowded toward outer end; additional trichia on outer half

of each of veins M_{1+2} and M_3. Venation: Sc_1 ending about opposite three-fifths the length of Rs, Sc_2 not far from its tip; R_2 a trifle shorter than R_{2+3}; basal section of R_{4+5} about twice R_{2+3}; m-cu opposite the proximal third of Rs.

Abdomen entirely red in male, the subterminal segments of female blackened.

LUZON, Tayabas Province, Candelaria, June 25, 1930 (*McGregor and Rivera*); holotype, male; allotype, female. "This red fly is found on damp mossy rocks at streamside."—McGregor.

Orimarga rubricolor is readily told by the conspicuous red coloration of the body.

HELIUS (RHAMPHOLIMNOBIA) RETICULARIS (Alexander).

Rhampholimnobia reticularis ALEXANDER, Proc. U. S. Nat. Mus. 49 (1915) 169–170.

One male, Pakawan, Ifugao Subprovince, Mountain Province, Luzon, April 7, 1930 (*Rivera*). The species and the subgenus are new to Luzon and the Philippines, having previously been recorded only from Java (type locality) and Borneo.

HEXATOMINI

EPIPHRAGMA (POLYPHRAGMA) BAKERI Alexander. Plate 1, fig. 12; Plate 2, fig. 32.

Epiphragma bakeri ALEXANDER, Philip. Journ. Sci. 21 (1922) 373–374.

A male from Pauai, Mountain Province, Luzon, altitude 8,000 feet, April 11, 1930 (*Rivera*), is generally similar to the holotype male except in the more-restricted brown wing pattern. The venation (Plate 1, fig. 12) has never been shown. The male hypopygium (Plate 2, fig. 32) is very different from that of the other Luzon species of the subgenus so far described. Region of the tergite, 9*t*, produced medially into a shield-shaped area, the caudal margin of which is deeply notched. Basistyle, *b*, with a small fleshy lobe on mesal face at base. Interbasal process, *i*, expanded on basal half, the apex unequally bidentate. Outer dististyle, *od*, a small bottle-shaped structure, the apex bent at a right angle into two subequal teeth. Inner dististyle, *id*, larger, flattened. Ædeagus large, with an irregular elevated crest.

EPIPHRAGMA (POLYPHRAGMA) PARVILOBA sp. nov. Plate 1, fig. 13; Plate 2, fig. 33.

Male.—Length, about 6.5 to 7 millimeters; wing, 7.5 to 8.

Generally similar to *E.* (*P.*) *ochrinota* Alexander in the general coloration of the body, differs most conspicuously in the dark

antennæ, narrow anterior vertex, wing pattern, and details of the male hypopygium.

Antennal scape black, the fusion segment infuscated, in cases a little brightened beneath. Head brownish gray, the anterior vertex very narrow, the eyes unusually large.

Mesonotum fulvous, contrasting markedly with the black pleura. Femora yellow, the subterminal darkening relatively pale and ill-defined. Wings (Plate 1, fig. 13) grayish, the costal region light yellow; a diffuse brown pattern, darker and more clearly delimited along the costal margin, the markings of the disk not bordered by yellow, as is the case in *E. ochrinota.*

Male hypopygium (Plate 2, fig. 33) with the median tergal lobes, 9*t*, very small, separated by a broad U-shaped notch. Basistyles very long and slender. Outer dististyle, *od*, dilated at midlength, setiferous, thence narrowed to an acute curved point, with a small lateral tubercle before apex. Interbasal process, *i*, a long simple spine, more slender than in *ochrinota.* Phallosome, *p*, with the ædeagus set in a deep notch in the quadrate plate.

LUZON, Laguna Province, above Ube, foot of Mount Banahao, altitude 400 to 700 meters, February 3 to 9, 1930 (*McGregor and Rivera*); holotype, male; paratypes, 3 males. The holotype was taken at 700 meters, in flight near river in cool forest.

LIMNOPHILA (EPHELIA) IGOROTA sp. nov. Plate 1, fig. 14; Plate 3, fig. 34.

Antennal scape black, the flagellum chiefly pale; mesonotal præscutum yellow, with abundant dark markings; knobs of halteres blackened; femora yellow, the tips more yellowish brown, with a very narrow black subterminal ring; wings broad in male, the dark pattern compact; seam on m-cu narrow, disconnected with the major area on the anterior cord.

Male.—Length, about 5.5 millimeters; wing, 6.5

Female.—Length, about 7 millimeters; wing, 7.5

Antennæ with the scapal segments dark brown, the first segment pruinose; flagellum with the basal six to eight segments light yellow. Head yellow, mottled with blackish.

Mesonotal præscutum with the ground color yellow, the usual stripes much dissected; lateral stripes entire, connected at anterior ends with the pseudosutural foveæ and confluent laterally with the broad dark brown lateral margins of the sclerite; median præscutal stripe blackened behind the level of the pseudosutural foveæ, the anterior portion wider, more grayish yellow, mottled with darker dots and with a capillary black vitta; in-

terspaces behind the pseudosutural foveæ with four or five dots that are in part confluent. Pleura gray, with numerous conspicuous brown spots that scarcely assume the form of a stripe. Halteres with the knobs black. Legs with the femora yellow, the tips light yellowish brown, the proximal end of this darkened ring narrowly blackened, as in *L. granulata*. Wings (Plate 1, fig. 14) of male broader than in female; dark pattern more restricted to the costal half, especially of the area along the cord, which forms an almost solid mass that extends back to the fork of M, the clear area in cell C greatly restricted, not reaching any of the veins of Rs; the very narrow seam along m-cu is not connected with the mark along the anterior cord, the Y-shaped figure in *granulata* thus appearing more V-shaped; seam on m-cu not in alignment with the anterior cord, being at or beyond midlength of cell 1st M_2; dark seam on the supernumerary crossvein in cell M a little distad of the general level of the dark areas that form the first crossband; dark spot beyond the prearcular area very small and inconspicuous.

Male hypopygium with the apical notch of the outer dististyle, *od* (Plate 3, fig. 34), broad and shallow, the margin irregular, the outer apical angle a decurved spine, preceded by a group of from five to seven smaller appressed spines; on lateral margin of style at near midlength with a conspicuous appressed spinous lobe.

LUZON, Mountain Province, Benguet, La Trinidad, below Baguio, altitude 4,800 feet, in open parklike area, March 26, 1930 (*Rivera*); holotype, male; allotype, female; Mount Santo Tomas, above Baguio, altitude over 5,000 feet, March 21, 1930 (*Rivera*); paratype, female; Pauai, April 21, 1930 (*Rivera*); paratype, 1 male; Laguna Province, above Ube, altitude 1,500 feet, February 11, 1930 (*Rivera*); paratypes, 2 males.

Limnophila (*Ephelia*) *igorota* is closely allied to the Bornean *L.* (*E.*) *granulata* Edwards, differing especially in the details of wing pattern and venation, the black knobs of the halteres, and other details.

PILARIA PHŒNOSOMA sp. nov. Plate 1, fig. 15; Plate 3, fig. 35.

General color red; antennæ short in both sexes; halteres black; wings with a strong brown tinge; vein R_3 very short, not exceeding one-third the length of the long R_4, cell R_3 at margin thus being very wide; cell M_1 lacking.

Male.—Length, about 7.5 to 8.5 millimeters; wing, 7 to 8.5.

Female.—Length, about 10 millimeters; wing, 7.5.

Rostrum and palpi black. Antennæ short in both sexes; scapal segments reddish brown; flagellum black; flagellar segments short and crowded, the outer segments passing into cylindrical; all segments with long conspicuous verticils that exceed the segments. Head fiery orange; vertex broad.

Thoracic dorsum fiery reddish orange, the præscutum without distinct stripes except a vague median capillary darkening; pseudosutural foveæ extensive but pale reddish and so inconspicuous; tuberculate pits at cephalic margin of sclerite reddish; scutellum brownish testaceous. Pleura reddish, vaguely marked with darker on the anepisternum and sternopleurite, the posterior sclerites more testaceous. Halteres black, the extreme base of stem brightened. Legs with the coxæ and trochanters obscure yellow; femora obscure brownish yellow, the tips narrowly blackened; tibiæ and tarsi black. Wings (Plate 1, fig. 15) with a strong brownish tinge, the small oval stigma darker brown; prearcular and costal regions a little brighter, especially before and beyond the stigma; conspicuous longitudinal hyaline obliterative streaks in cells R, R_3, M, 1st M_2, M_3, and M_4; veins dark brown. Venation: Sc relatively long, Sc_1 ending opposite the fork of Rs, Sc_2 some distance from its tip, Sc_1 alone exceeding R_{2+3+4}; R_3 very short, not exceeding one-third the length of the long R_4, cell R_3 at margin, thus being very wide; cell M_1 lacking; m-cu about one-third to one-half its length beyond the fork of M; anterior arculus preserved.

Abdomen reddish, the caudal margins of the tergites narrowly but conspicuously blackened; hypopygium orange-yellow. Male hypopygium (Plate 3, fig. 35) with the tergite, 9*t*, conspicuous, the median portion of the caudal margin produced into a broad lobe that is further produced into two submedian glabrous plates, their tips obtuse, these plates separated by a deep notch. Basistyles, *b*, short and stout. Dististyles, *id*, *od*, as figured, the inner style very broad.

LUZON, Laguna Province, Ube, February 11 to May 9, 1930 (*McGregor and Rivera*); holotype, male; allotype, female; paratopotypes, 15 of both sexes.

Pilaria phœnosoma is very different from all described members of the genus, in some respects more resembling a small *Eriocera*. The following notes on the occurrence of this species are of much interest: "The water supply for Majayjay comes from a large spring near Ube. The overflow runs off in a small stream and is used for irrigation. Just below the spring is

a small bog (area approximately one hectare). Some of this is open, with growth of ferns, sedges, and small shrubs. A large part is covered with a bamboo and pandan thicket. Many of the mountain streams are dry this month (March), but this spring seems to have the same overflow as in the rainy months. In ferns and other low vegetation along this stream and in plants on this boggy area, many large and small tipulids occurred."—McGregor. Associated with the *Pilaria* in this habitat on March 4, 1930, were the following Tipulidæ: *Limonia* (*Geranomyia*) *argentifera* (de Meijere), *L.* (*Goniodineura*) *nigriceps* (van der Wulp), *L.* (*Thrypticomyia*) *apicalis* (Wiedemann), *Conosia irrorata* (Wiedemann), *Trentepohlia* (*Trentepohlia*) *trentepohlii* (Wiedemann), *Gonomyia* (*Lipophleps*) *bicolorata* Alexander, and *Erioptera* (*Erioptera*) *rubripes* Alexander.

PILARIA CARBONIPES sp. nov. Plate 1, fig. 16.

General coloration of mesonotum polished black, the thoracic pleura abruptly yellow; antennæ (male) elongate; halteres and legs black; wings with a blackish tinge; R_2 shorter than R_{2+3}; cell M_1 present; hypopygium black.

Male.—Length, about 4 to 4.2 millimeters; wing, 4.3 to 5; antennæ, 2.3 to 2.6.

Female.—Length, about 5 millimeters; wing, 4.6 to 5.

Antennæ (male) elongate, much exceeding one-half the length of the body, black throughout; flagellar segments cylindrical to elongate-fusiform, with dense erect black setæ and slightly longer verticils. In the female the antennæ are shorter, about equal to the combined head and thorax, the setæ lacking or inconspicuous, the verticils very long and evident. Head polished black.

Mesonotum polished black, the humeral region of præscutum very restrictedly pale. Pleura, including the pleurotergite, yellow. Halteres blackened. Legs with the coxæ and trochanters obscure yellow; remainder of legs black, only the femoral bases restrictedly obscure yellow. Wings (Plate 1, fig. 16) with a strong blackish tinge, the oval stigma slightly darker brown; veins brownish black. Venation: Sc_1 ending about opposite four-fifths the length of Rs, Sc_2 at its tip; R_{2+3} present, a little longer than R_2 alone; R_3 long, straight or weakly sinuous; inner ends of cells R_4, R_5, and 1st M_2 in oblique alignment, the last most basad; cell M_1 slightly longer than its petiole; m-cu beyond midlength of cell 1st M_2.

Abdominal tergites and hypopygium black, the sternites abruptly light yellow.

LUZON, Laguna Province, above Ube, February 11 to April 14, 1930 (*McGregor and Rivera*); holotype, male; allotype, female; paratypes, 6 of both sexes; Mount Maquiling, January 28, 1930 (*Duyag*); paratype, female.

Pilaria carbonipes is somewhat similar to the Japanese *P. melanota* Alexander, differing in the more-blackened notum, the black legs, and strongly infumed wings, with the venational details quite distinct, notably the position of R_2 and the course of R_3.

PILARIA CARBONIPES HOLOMELANIA subsp. nov.

As in the typical form, but the pleura and pleurotergite polished black. The legs, especially the tarsi, paler, the tarsi fading to yellowish white.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,800 feet, July 3, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 1 male, 1 female.

PILARIA ALBOPOSTICATA sp. nov.

Male.—Length, about 5 to 5.2 millimeters; wing, 6; antennæ, 2.8 to 3.

Female.—Length, about 5.5 millimeters; wing, 5.5.

Characters much as in *P. carbonipes* sp. nov., differing as follows: Legs black, the femoral bases obscure yellow, especially the posterior femora; tarsi black, the posterior tarsi conspicuously whitish yellow, the two terminal segments darkened.

LUZON, Laguna Province, above Ube, February, 1930 (*Rivera*); holotype, male; paratypes, 3 males; Mountain Province, Benguet, La Trinidad, below Baguio, altitude 4,800 feet, March 26 to 28, 1930 (*Rivera*); allotype, female; paratypes, 3 of both sexes.

The conspicuous pale coloration of the posterior tarsi is distinctive of the species.

ERIOPTERINI

GONOMYIA (LIPOPHLEPS) MAQUILINGIA sp. nov. Plate 1, fig. 17; Plate 3, fig. 36.

General coloration brownish gray; rostrum orange; antennæ black throughout; thoracic pleura indistinctly variegated yellowish testaceous and pale brown; legs brownish black; wings tinged with brownish gray, the stigma only vaguely darker; Sc short; male hypopygium with a single small subterminal dis-

tistyle; phallosomic structure terminating in a median organ shaped like a tuning fork.

Male.—Length, about 3 millimeters; wing, 3.

Rostrum orange; palpi black. Antennæ black throughout. Head chiefly gray.

Mesonotum brownish gray, the median region of the scutum slightly paler; posterior callosities of scutal lobes and the scutellum obscure yellow, the median region of the latter at base darkened; postnotal mediotergite pruinose. Pleura vaguely patterned with yellowish testaceous and pale brown, the pale coloration including the posterior sclerites; dorsal pleurites and ventral sternopleurite darkened. Halteres dusky, the base of stem restrictedly brightened. Legs with the coxæ and trochanters testaceous-brown; remainder of legs brownish black. Wings (Plate 1, fig. 17) tinged with brownish gray, the stigma slightly and vaguely darkened; veins brown. Venation: Sc short, Sc_1 ending a short distance before origin of Rs, this distance greater than the length of the latter; Rs less than two-thirds the anterior branch of the same; cell 1st M_2 closed; m-cu before fork of M.

Abdominal tergites brown, paler laterally, the sternites more uniformly pale. Male hypopygium (Plate 3, fig. 36) with the apical lobe of basistyle, *b*, slender. Dististyle, *d*, single, pale, much shorter and more slender than the lobe of the basistyle, provided with about six setæ. Phallosomic structure, *p*, consisting of a pale fan-shaped plate, its caudal margin with four low crenulate lobes; a further median extension is shaped like a tuning fork.

LUZON, Laguna Province, Mount Maquiling, May 23 to 30, 1930 (*Duyag*); holotype, male.

Gonomyia (*Lipophleps*) *maquilingia* is generally similar to *G.* (*L*). *incompleta* Brunetti, differing decisively in the very different male hypopygium.

GONOMYIA (LIPOPHLEPS) INCOMPLETA Brunetti.

Gonomyia incompleta BRUNETTI, Fauna British India, Dipt. Nematocera (1912) 471–472.

Gonomyia (*Leiponeura*) *insulensis* ALEXANDER, Can. Ent. 45 (1913) 286–287.

LUZON, Laguna Province, Ube, February 6, 1930 (*Rivera*); Tayabas Province, Candelaria, June 25, 1930 (*McGregor and*

Rivera). This fly has a very extensive range in eastern Asia, from British India to Japan.

GONOMYIA (LIPOPHLEPS) PALLIDISIGNATA sp. nov. Plate 1, fig. 18; Plate 3, fig. 37.

General coloration brown to grayish brown; basal segments of flagellum yellow, the outer segments blackened; pleura with a whitish longitudinal stripe; legs with the femora pale brown, the tips whitish, inclosing a very broad black subterminal ring; tibiæ pale brown, the tips narrowly pale yellow; wings white, clouded with pale brown; Rs from one-third to one-half longer than the petiole of cell R_3; male hypopygium with three dististyles.

Male.—Length, about 2.8 millimeters; wing, 3.

Female.—Length, about 3.5 millimeters; wing, 3.5.

Rostrum and palpi black. Antennæ with the scape above and basal two segments of flagellum yellow, the remainder of the organ blackened. Head white, the center of the vertex extensively blackened.

Pronotum and anterior lateral pretergites white. Mesonotum brown, varying from reddish brown to dark grayish brown, the scutal lobes darker; scutellum obscure white, the median area darkened at base; postnotum dark. Pleura brown to brownish black, usually blue-gray pruinose, with a narrow, conspicuous, longitudinal white stripe extending from and including the fore coxæ, passing beneath the halteres, this stripe sometimes obscured or lost. Halteres yellow, the base of the club darkened. Legs with the fore coxæ white, the mid-coxæ dark brown, the posterior coxæ dark brown on basal half, white on distal half; trochanters whitish; femora beyond base pale brown, with a very broad and conspicuous black subterminal ring, preceded and followed by narrow white annuli that are less than one-third the area of the blackened annulus; tibiæ pale brown, the tips narrowly pale yellow; tarsi brown. Wings (Plate 1, fig. 18) with the ground color white, this including the prearcular, costal, and apical portions; remainder of disk clouded with pale brown, reducing the ground color to areas in both ends of cells R and M, a more or less distinct crossband beyond the cord, and the outer ends of cells Cu and 1st A; restricted darker brown areas at origin of Rs and tip of Sc, stigma, ends of veins R_3 and R_4, and along the cord; veins brown, pale in the ground areas. Venation: Sc_1 ending opposite or shortly beyond origin of Rs, the latter unusually long for this subgenus, being about one-third

to one-half longer than the straight petiole of cell R_3; R_3 short and transverse, R_4 strongly arcuated; m-cu before the fork of M.

Abdomen brownish black, including the hypopygium; caudal margins of abdominal segments narrowly and indistinctly paler. Male hypopygium (Plate 3, fig. 37) with three dististyles, the outer a long, gently curved, blackened rod; intermediate style very small, appearing as a pale spine; innermost style long-oval, terminating in two long setæ.

LUZON, Laguna Province, Ube and above, altitude 400 to 700 meters, February 6 to April 14, 1930 (*McGregor and Rivera*); holotype, male; allotype, female; numerous paratypes of both sexes.

Although closely allied to *G.* (*L.*) *nubeculosa* de Meijere, I must regard the present fly as being distinct, differing especially in the coloration of the legs and wings and the longer Rs. I do not have a male of *nubeculosa* for comparison. The African species, *G.* (*L.*) *liberiensis* Alexander, *G.* (*L.*) *noctabunda* Alexander, and *G.* (*L.*) *sobrina* Alexander, are also allied though separable on venation and structure of the male hypopygium. Edwards is entirely correct and justified in referring this group of flies with cell R_3 preserved to *Lipophleps* rather than to the typical subgenus where they had been placed by other workers.

GONOMYIA (LIPOPHLEPS) ALBOANNULATA sp. nov. Plate 1, fig. 19; Plate 3, fig. 38.

Closely related to *G. diffusa;* rostrum and palpi black; basal segments of antennal flagellum pale; thoracic pleura with a narrow white line; halteres with darkened knobs; femora brownish yellow, with a brown subterminal ring, preceded and followed by clear yellow; wings unmarked except for a vague pale brown stigmal area; anterior branch of Rs gently sinuous; male hypopygium with three dististyles, the intermediate one spinous at apex, the inner style split into three acute spines.

Male.—Length, about 2.6 millimeters; wing, 3.3.

Female.—Length, about 3 millimeters; wing, 3.2.

Rostrum relatively elongate, about one-half the remainder of head, black; palpi black. Antennæ with the scape dark brown, the basal flagellar segments pale, the outer segments passing into dark brown. Head pale, the center of the vertex restrictedly darkened.

Anterior pronotum whitish, with a darkened median spot; anterior lateral pretergites whitish. Mesonotum grayish brown, the pseudosutural foveæ dark brown; median region of scutum

and narrow posterior margin of scutellum obscure testaceous; postnotal mediotergite brownish gray, the anterior lateral angles broadly yellow. Pleura brownish black on ventral half, this inclosing a conspicuous white longitudinal stripe, bordered on either side by blackish; dorsopleural region buffy, more blackened in front. Halteres pale, the knobs brown. Legs with the fore and hind coxæ pale, the mid-coxæ dark brown; trochanters yellow; femora brown to yellowish brown, with a broad brown subterminal ring, preceded and followed by a narrow clearer yellow ring; tibiæ white, the tips narrowly blackened; tarsi white, the tips dark brown. Wings (Plate 1, fig. 19) grayish, unmarked except for a vague pale brown stigmal area; prearcular and costal regions more yellowish; veins pale brown. Venation: Sc_1 ending opposite the origin of the strongly arcuated Rs; anterior branch of Rs gently sinuous.

Abdomen of male dark brown, including the hypopygium; caudal margins of segments conspicuously ringed with pale; pleural membrane conspicuously whitened. In female, the segments are uniformly darkened, as in *diffusa*. Male hypopygium (Plate 3, fig. 38) with three dististyles, the outermost a simple blackened blade, gradually narrowed to the obtuse tip; intermediate style a little shorter, appearing as a straight rod, the distal third slightly expanded into a spinous head; innermost style, *id*, trifid, all arms acute, the laterals straight and provided with two or three setæ, the central arm curved, glabrous.

LUZON, Tayabas Province, Candelaria, along margin of stream, June 25, 1930 (*McGregor and Rivera*); holotype, male. MINDANAO, Davao district, Calian, Lawa, at trap lantern, April 24, 1930 (*Clagg*); allotype, female; paratype, female.

Gonomyia (*Lipophleps*) *alboannulata* is most closely allied to *G.* (*L.*) *diffusa* (de Meijere), differing especially in the darkened knobs of the halteres, the details of venation, as the strongly sinuous anterior branch of Rs, and the pattern of the legs and wings. I do not know the male sex of *diffusa*.

GONOMYIA (LIPOPHLEPS) LUTEIMARGINATA sp. nov. Plate 3, fig. 39.

Male.—Length, about 2.6 millimeters; wing, 3.3.

Characters as in *G. flavomarginata* (Brunetti), differing in details of coloration of the wings and legs.

Thoracic pleura plumbeous-brown, with a single narrow whitish longitudinal stripe. Legs with the femora brownish yellow, with a narrow and ill-delimited brown ring just before

the tip; tibiæ and tarsi dark brown. Wings gray, with a vague brownish gray pattern, the clearer areas lying chiefly before and beyond the cord, which is broadly and distinctly seamed with brownish gray; prearcular and costal regions pale yellowish white; whitish areas before and beyond stigma; veins very pale brown, the costal and subcostal veins pale yellow, the cord darkened. Venation: Sc_1 ending a short distance before the origin of Rs, this distance about equal to the basal section of R_5; anterior branch of Rs straight or very gently sinuous.

Male hypopygium (Plate 3, fig. 39) with the outer dististyle, *od*, a gently curved blackened rod, the apex obtuse, near base on mesal edge produced into a curved black spine, the margin with conspicuous appressed spines. Inner dististyle, *id*, a straight yellow rod, the tip produced into a small blackened recurved spine. Phallosome, *p*, terminating in two blackened points, each produced cephalad into a long black spine.

MINDANAO, Davao district, Calian, Lawa, April 24, 1930, at trap lantern (*Clagg*); holotype, male.

This species agrees very closely with *flavomarginata* (Brunetti) except in the details indicated. Edwards,[2] who examined paratypes of this species, states that all the veins of the wings are brownish. The Japanese *G.* (*L.*) *flavocostalis* Alexander is likewise generally similar but differs in all details of the male hypopygium. The outer dististyle is only weakly spinous along margin; the inner dististyle is triangular in outline, the outer end of the triangle being a long pale spine; phallosome not blackened at tips.

GONOMYIA (LIPOPHLEPS) SECRETA sp. nov. Plate 1, fig. 20; Plate 3, fig. 40.

General coloration brown; basal segments of antennæ reddish orange; pleura dark, with a longitudinal, light yellow stripe; knobs of halteres yellow; legs yellowish brown, without femoral rings; wings cream-yellow, with conspicuous pale brown clouds and washes; Sc_1 ending a short distance before the origin of Rs; male hypopygium with two dististyles, the outer a powerful chitinized rod, its tip bifid.

Male.—Length, about 2.5 millimeters; wing, 2.5.

Female.—Length, about 4 millimeters; wing, 3.5.

Rostrum and palpi black. Antennæ with the basal segments reddish orange, the flagellum black. Head pale yellow, the center of the vertex darkened.

[2] Rec. Indian Mus. 26 (1924) 301.

Pronotum and anterior lateral pretergites light yellow. Mesonotal præscutum brown with a faint grayish bloom; humeral region restrictedly obscure yellow, the pseudosutural foveæ reddish brown; females with a capillary darker brown median line on præscutum; scutal lobes dark brown, the median area and restricted caudal-lateral angles of the lobes yellow; scutellum yellow with a conspicuous brown median spot; postnotal mediotergite brown, the cephalic-lateral portions more yellowish. Pleura dark brown, with a longitudinal, light yellow stripe that is bordered both above and below by scarcely apparent blackish darkenings. Halteres dusky, the knobs yellow. Legs with the fore coxæ light yellow, the remaining coxæ brownish testaceous, trochanters obscure yellow; remainder of legs pale yellowish brown, unvariegated, the outer tarsal segments darker brown. Wings (Plate 1, fig. 20) cream-yellow, with conspicuous pale brown clouds and washes, including a major area in cell R before Rs; the cord and outer end of cell 1st M_2; conspicuous longitudinal seams along veins Cu as far as m-cu, cell Cu at base and along vein 1st A for more than one-half the length; axilla infumed; stigmal region scarcely darkened; veins pale yellow, very indistinct, more darkened in the clouded areas. Venation: Sc_1 ending shortly before the origin of Rs, Sc_2 near its tip; Rs strongly arcuated; anterior branch of Rs nearly straight; cell 1st M_2 closed; m-cu a short distance before the fork of M.

Abdominal tergites light brown, the anterior-lateral margins light yellow, the more extensive posterior-lateral margins velvety black; sternites more uniformly darkened; hypopygium brownish yellow. In female, the tergites blackened, with a restricted yellow area at each cephalic-lateral angle. Male hypopygium (Plate 3, fig. 40) with only two dististyles, the outer, *od*, a powerful chitinized rod, the stem straight, the head more enlarged and bifid, the more slender arm fingerlike, the other arm flattened, terminating in a comb of microscopic teeth; inner margin of stem with a row of powerful fasciculate setæ. Inner dististyle a small pale blade, the tip obtuse. Phallosome, *p*, complex.

LUZON, Laguna Province, Ube, February 11 to March 3, 1930 (*McGregor and Rivera*); holotype, male; allotype, female; paratypes, 2 females.

Gonomyia (*Lipophleps*) *secreta* by Edward's key to the species of the subgenus [3] runs to *G.* (*L.*) *robinsoni* Edwards (Malay States), a very different fly.

[3] Journ. Fed. Malay St. Mus. 14 (1928) 104–105.

GONOMYIA (PTILOSTENA) PUNCTIPENNIS Edwards.

Gonomyia (*Ptilostena*) *punctipennis* EDWARDS, Treubia 7 (1926) 140–141.

A few of both sexes, Lawa, Davao district, Mindanao, taken at trap lantern, May 5, 1930, by Charles F. Clagg. The species was described from Buru and will probably be found to be a widely distributed species in the Malayan and Moluccan islands.

TEUCHOLABIS (TEUCHOLABIS) MAJUSCULA sp. nov. Plate 1, fig. 21; Plate 3, fig. 41.

General coloration yellow and black; præscutal stripes confluent; pleura black, striped longitudinally with yellow; knobs of halteres obscure orange; legs entirely black; wings yellow, the outer radial cells slightly infumed; male hypopygium with the outer dististyle a macelike capitate structure.

Male.—Length, about 9 millimeters; wing, 8.

Rostrum nearly as long as remainder of head, black; palpi black. Antennæ black throughout; basal flagellar segments short-oval, becoming smaller and more elongate outwardly. Head black, the front and wide anterior vertex sparsely dusted with gray.

Pronotum very large, yellow. Mesonotal præscutum chiefly occupied by three confluent polished black stripes, leaving yellow areas at the humeri, a transverse median area at the suture and a tiny spot at each posterior-lateral angle; scutum yellow, each lobe chiefly covered by polished black centers; scutellum deep yellow; postnotal mediotergite yellow on cephalic third, the remainder black. Pleura black, with a conspicuous yellow longitudinal stripe that extends from behind the fore coxæ, passing beneath the halteres to the abdomen; dorsopleural region yellow. Halteres dusky, the knobs obscure orange. Legs with the fore coxæ reddish, the remaining coxæ and all trochanters black; remainder of legs entirely black. Wings (Plate 1, fig. 21) with a strong yellow tinge, the outer radial cells slightly more infumed; anterior prearcular cells infuscated; veins black. Venation: Sc long, Sc_1 ending about opposite four-fifths the length of Rs, Sc_2 at near midlength of this vein; R_1 in alignment with R_{1+2}; cell 1st M_2 elongate, parallel-sided; m-cu more than its own length beyond the fork of M.

Abdomen bicolorous, black, the incisures more narrowly orange, on the tergites this color wider on the caudal margins than on the bases of the segments. Male hypopygium (Plate 3, fig. 41) with the tergal region narrowly emarginate medially; sternite, 9*s*, convexly rounded, with abundant setæ, especially on

sides. Basistyle, *b*, with the dorsal-apical angle produced into a black spine; the ventromesal angle with irregular blackened teeth. Outer dististyle, *od*, a mace-shaped structure, as figured. Inner dististyle, *id* longer, the basal half wider, the distal half gradually narrower and angularly bent, with three setæ at the angulations, the apex an acute black spine. Phallosome, *p*, with a wider dorsal and a narrow ventral plate, both tipped with long conspicuous setæ.

MINDANAO, Davao district, Lawa, April 18, 1930, at trap lantern (*Clagg*); holotype, male.

Teucholabis (*Teucholabis*) *majuscula* is one of the largest species of the genus, though exceeded in size by the allied *T.* (*T.*) *nigerrima* Edwards (Formosa). Both of these species have R_1 in alignment with R_{1+2}, the veins not dipping slightly caudad at the point of union with R_2 as is the case in virtually all other species of this extensive genus.

TEUCHOLABIS (TEUCHOLABIS) CONFLUENTOIDES sp. nov. Plate 1, fig. 22; Plate 3, figs. 42 and 43.

Male.—Length, about 6.5 to 7 millimeters; wing, 6 to 6.5. Generally similar to *T.* (*T.*) *confluenta* Alexander (Luzon), differing especially in the structure of the male hypopygium and the details of venation.

Pronotum extensively pale yellow. Mesonotal præscutum black, the humeral triangles extensively and conspicuously light yellow; scutal lobes blackened, the median region broadly yellow, crossing the suture onto the præscutum. Dorsopleural region clearer yellow. Wings (Plate 1, fig. 22) with the pattern banded, much as in *confluenta*. Venation: Cell 2d M_2 much deeper, exceeding its petiole. Male hypopygium (Plate 3, fig. 42) with the spine of the basistyle, *b*, simple. Outer dististyle, *od*, with two, or in cases, a minute third, spine, in addition to the long curved apex. Inner dististyle, *id*, with a bisetose lobe at base and on obtuse lobule in addition to the long spinous point.

In *confluenta* (Plate 3, fig. 43) the spine of the basistyle, *b*, is forked. Outer dististyle, *od*, a long sinuous rod, with a single small spine at near midlength. Inner dististyle, *id*, a simple black rod.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 to 5,800 feet, July 2 to 3, 1930 (*Clagg*); holotype, male; paratypes, 4 males. "Dancing above ferns in semitwilight of dense mossy forest."—Clagg.

ILLUSTRATIONS

[Legend: *a*, ædeagus; *b*, basistyle; *d*, dististyle; *dd*, dorsal dististyle; *g*, gonapophysis; *i*, interbasal process; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome; *s*, 9th sternite; *t*, 9th tergite; *vd*, ventral dististyle.]

Plate 1

Fig. 1. *Limonia* (*Limonia*) *candidella* sp. nov., wing.
2. *Limonia* (*Limonia*) *latiflava* sp. nov., wing.
3. *Limonia* (*Limonia*) *flavohumeralis* sp. nov., wing.
4. *Limonia* (*Limonia*) *canis* sp. nov., wing.
5. *Limonia* (*Rhipidia*) *luteipleuralis* sp. nov., wing.
6. *Limonia* (*Geranomyia*) *phœnosoma* sp. nov., wing.
7. *Limonia* (*Geranomyia*) *longifimbriata* sp. nov., wing.
8. *Limonia* (*Geranomyia*) *paramanca* sp. nov., wing.
9. *Limonia* (*Pseudoglochina*) *angustapicalis* sp. nov., wing.
10. *Limonia* (*Alexandriaria*) *sollicita* sp. nov., wing.
11. *Orimarga* (*Orimarga*) *rubricolor* sp. nov., wing.
12. *Epiphragma* (*Polyphragma*) *bakeri* Alexander, wing.
13. *Epiphragma* (*Polyphragma*) *parviloba* sp. nov., wing.
14. *Limnophila* (*Ephelia*) *igorota* sp. nov., wing.
15. *Pilaria phœnosoma* sp. nov., wing.
16. *Pilaria carbonipes* sp. nov., wing.
17. *Gonomyia* (*Lipophleps*) *maquilingia* sp. nov., wing.
18. *Gonomyia* (*Lipophleps*) *pallidisignata* sp. nov., wing.
19. *Gonomyia* (*Lipophleps*) *alboannulata* sp. nov., wing.
20. *Gonomyia* (*Lipophleps*) *secreta* sp. nov., wing.
21. *Teucholabis* (*Teucholabis*) *majuscula* sp. nov., wing.
22. *Teucholabis* (*Teucholabis*) *confluentoides* sp. nov., wing.

Plate 2

Fig. 23. *Scamboneura nigrotergata* sp. nov., male hypopygium, details.
24. *Scamboneura calianensis* sp. nov., male hypopygium, ninth tergite.
25. *Scamboneura calianensis* sp. nov., male hypopygium, outer dististyle.
26. *Limonia* (*Limonia*) *candidella* sp. nov., male hypopygium.
27. *Limonia* (*Limonia*) *flavohumeralis* sp. nov., male hypopygium.
28. *Limonia* (*Limonia*) *canis* sp. nov., male hypopygium.
29. *Limonia* (*Geranomyia*) *phœnosoma* sp. nov., male hypopygium.
30. *Limonia* (*Geranomyia*) *longifimbriata* sp. nov., male hypopygium.
31. *Limonia* (*Pseudoglochina*) *angustapicalis* sp. nov., male hypopygium.
32. *Epiphragma* (*Polyphragma*) *bakeri* Alexander, male hypopygium.
33. *Epiphragma* (*Polyphragma*) *parviloba* sp. nov., male hypopygium.

PLATE 3

FIG. 34. *Limnophila* (*Ephelia*) *igorota* sp. nov., male hypopygium, outer dististyle.
35. *Pilaria phœnosoma* sp. nov., male hypopygium.
36. *Gonomyia* (*Lipophleps*) *maquilingia* sp. nov., male hypopygium.
37. *Gonomyia* (*Lipophleps*) *pallidisignata* sp. nov., male hypopygium.
38. *Gonomyia* (*Lipophleps*) *alboannulata* sp. nov., male hypopygium.
39. *Gonomyia* (*Lipophleps*) *luteimarginata* sp. nov., male hypopygium.
40. *Gonomyia* (*Lipophleps*) *secreta* sp. nov., male hypopygium.
41. *Teucholabis* (*Teucholabis*) *majuscula* sp. nov., male hypopygium.
42. *Teucholabis* (*Teucholabis*) *confluentoides* sp. nov., male hypopygium.
43. *Teucholabis* (*Teucholabis*) *confluenta* Alexander, male hypopygium.

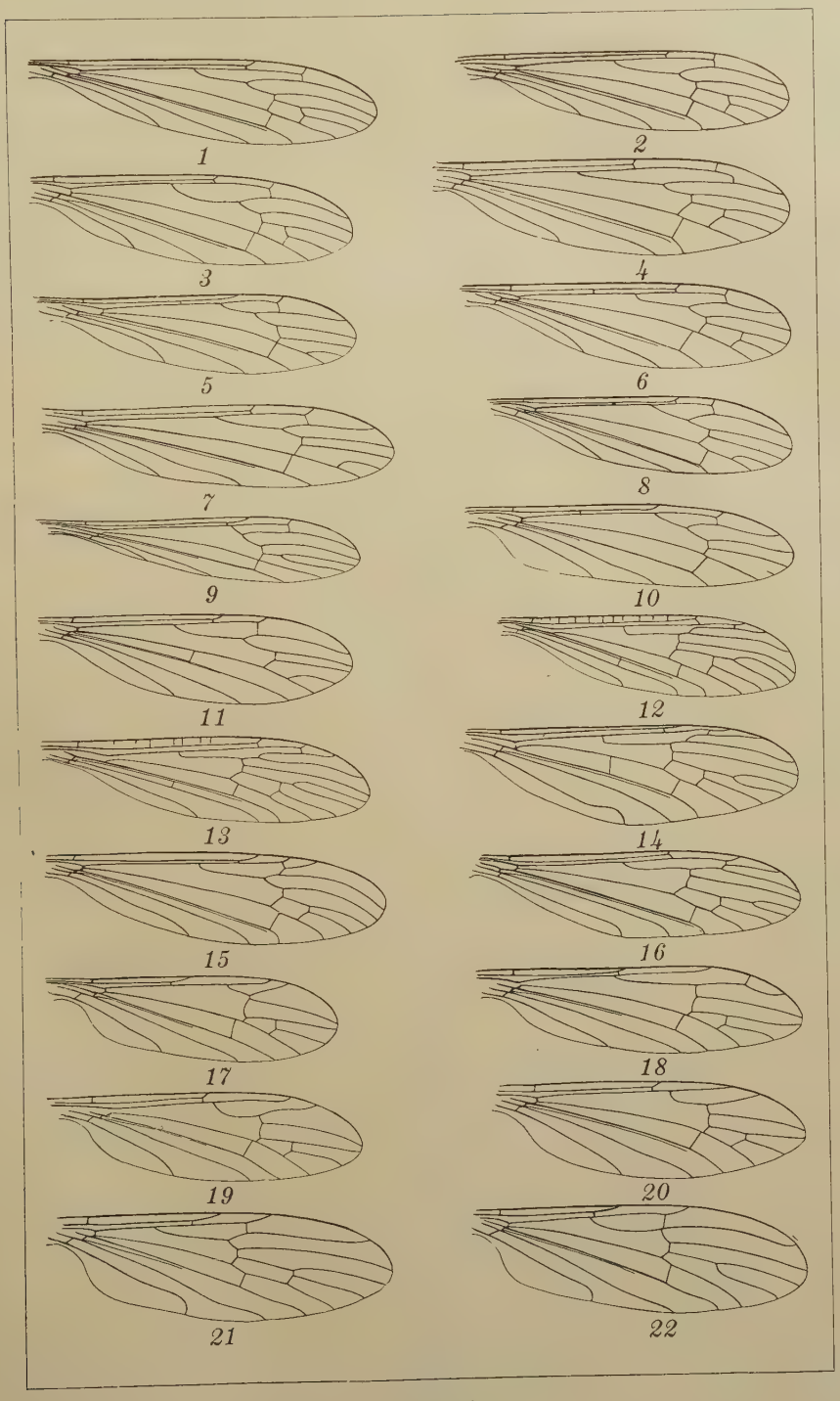

PLATE 1.

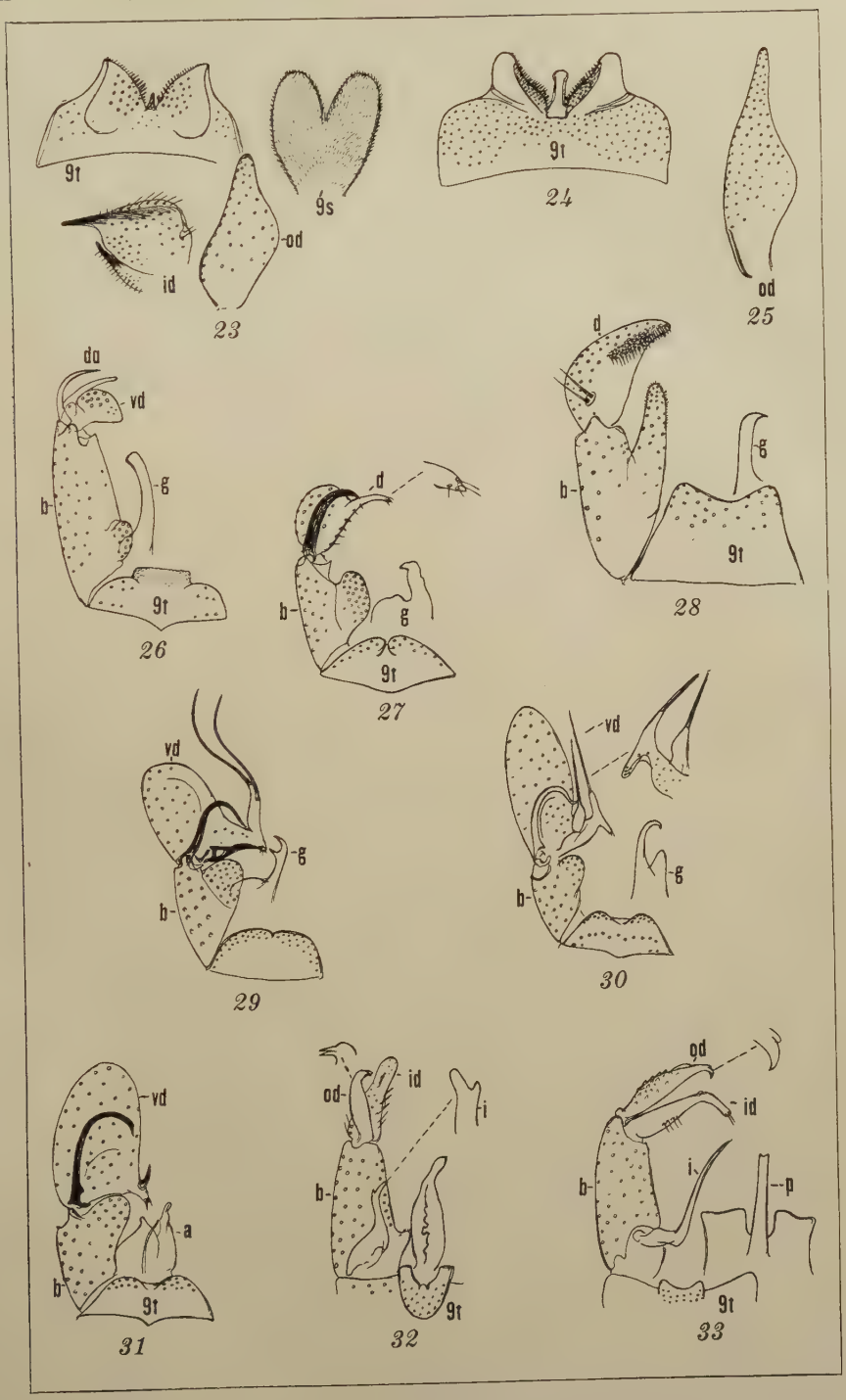
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PLATE 2.

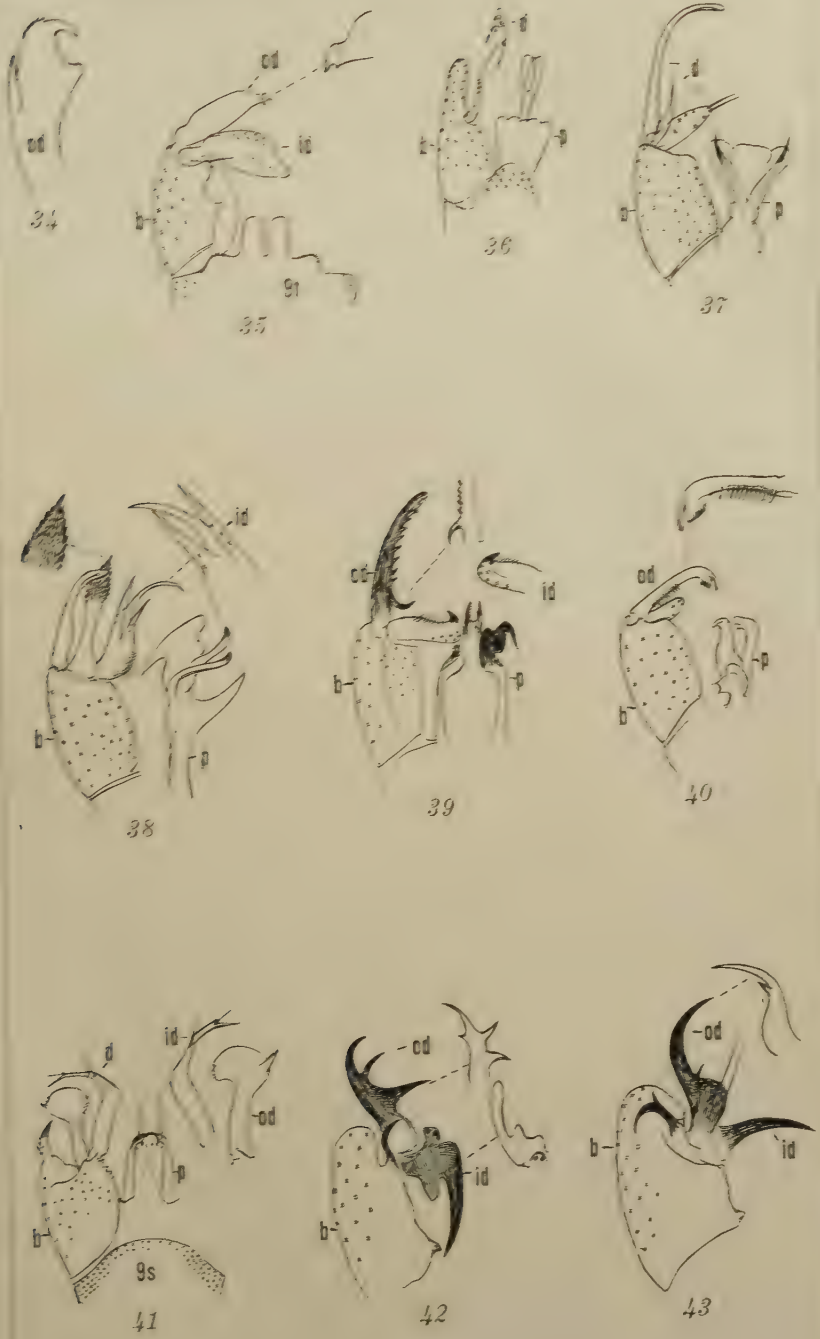

PLATE 3.

ORIGIN OF THE IRRITATING SUBSTANCE IN MOSQUITO BITE [1]

By C. MANALANG

Of the Philippine Health Service, Manila

ONE PLATE

Ludlow [2] mentioned the properties of the salivary-gland secretion among the problems concerning malarial infection of mosquitoes that need further investigation. She said:

> As far as I am aware, nobody has yet repeated Schaudinn's observations. He states that the salivary gland rubbed into an abrasion does not produce the irritation of mosquito bite, but that, on the contrary, if the œsophageal diverticula be rubbed in, the well known itching effects are experienced, which he attributes to the enzymes produced by low bacterial forms in the diverticula. Any facts established about mosquitoes is of value, for we never know to what practical purposes such knowledge may not be turned.

Castellani and Chalmers [3] said:

> There has been much dispute as to where this substance comes from, but this appears to have been settled by Schaudinn who triturated the isolated salivary glands in salt solution which he applied to a wound with negative results. On the other hand when he applied the isolated œsophageal diverticula to a scratch he obtained the characteristic irritation and redness. These œsophageal diverticula contain gas bubbles and bacteria or moulds. The bubbles were shown by Schaudinn to contain carbon dioxide by applying baryta-water to the diverticula, when a precipitate was obtained. The fungi need further investigation, but they or their products appear to be the real cause of irritation, for when Schaudinn expressed the carbon dioxide out of the sac the signs characteristic of the bite were still produced.

While dissecting anopheline mosquitoes for malarial parasites, I applied isolated glands to five separate needle scratches on the anterior surface of my forearm. In a few seconds I experienced itching, followed by the appearance of wheals around

[1] From the field laboratory of the division of malaria control, Philippine Health Service, Tungkong Manga, Bulacan.

[2] Surgeon General, U. S. Army, Bull. 4 (1913) 90.

[3] Manual of Tropical Medicine 3d ed. (1919) 224–225.

the edges of the scratches, then by a distinct redness of the surrounding skin in all the scratches. I repeated the test, using isolated gas-containing diverticula. Of the four trials, one scratch itched slightly, followed by a small area of redness around the scratch. The other three scratches did not show any reaction at all. With results unlike those of Schaudinn's, I repeated the experiment using more material and two methods (scratch and prick) of inoculation.

Most of the mosquitoes used were *Anopheles ludlowi* Theobald and *A. vagus* Donitz, which were the dominant species in the catches at the time. *Anopheles maculatus* Theobald, *A. aconitus* var. *filipinæ* Manalang, *Culex quinquefasciatus* Say, *Aëdes ægypti* Linnæus, a *Culex* species, four male *A. ludlowi*, and one male *C. quinquefasciatus* were also used.

The scratch method of inoculation seems to have the disadvantage of drawing blood, which may dilute or prevent the inoculum from penetrating the tissues. Light scratches may not be sufficient to permit its penetration. They may dry up in case of any delay in the inoculation. The prick on the other hand is more like the natural bite. With magnifying-lens control the inoculum can be picked up at the point of the needle. This facilitates the entrance of the inoculum at the first prick, or, if it fails and the inoculum is left on the skin, subsequent pricks (about twenty) on the same spot will succeed.

METHODS AND RESULTS

Scratch method.—The freshly killed mosquito is dissected in a drop of normal saline under a magnifying lens. Once the salivary gland and diverticulum are isolated a series of three shallow scratches, about 0.5 centimeter long and 2 centimeters apart, are made with a few strokes of a pointed needle on the anterior surface of the forearm. This surface is used because the reaction is clear, the skin being thinner and lighter in color than that on the posterior surface. With the aid of the magnifying lens the gland (usually three lobes from one side) is picked up with the needle and very lightly rubbed several times into one scratch. Wash the needle in saline, wipe dry, and repeat the process with the diverticulum (usually the abdominal) on the other scratch. The third or control scratch is inoculated with a minute quantity of salt solution from the same drop in which the mosquito has been dissected. This is done to detect any soluble substance from any organ which may give a re-

action. The results of the tests by this method are set forth in Table 1.

TABLE 1.—*Scratch tests.*

Organ tested.	Number of tests.	Positive.	Slightly positive.	Negative.
Salivary gland (from females)	30	30		
Salivary gland (from males)	2			2
Diverticulum	7	1	2	4
Stomach	4	1	1	2
Ova	1	1		
Malphigian tubes	1		1	
Parasites	1		1	
Control	10			10

Prick method.—After isolation, the organ to be tested is picked up on the point of the needle, then inoculated by twenty light pricks on a fixed point on the skin. I usually select the root of a hair or the edge of an ink mark. The prick should be just felt but not deep enough to draw blood. The results by this method are set forth in Table 2.

TABLE 2.—*Prick tests.*

Organ tested.	Number of tests.	Positive.	Slightly positive.	Negative.
Salivary gland (from females)	18	18		
Salivary gland (from males)	2		1	1
Diverticulum (from females)	10	9	1	
Diverticulum (from males)	3	3		
Stomach (females)	5	2	3	
Malphigian tubes	6	1	5	
Thoracic muscle	1			1
Testes	2	1		1
Œsophagus	1	1		
Ova	2	1	1	
Wing	2			2
Stomach (from males)	2	1	1	
Eye	1		1	
Parasite	1	1		
Brain	1			1
Control	12			12

A typical reaction starts with itching immediately followed by the appearance of a wheal, which enlarges and rises with increasing paleness in contrast with the spreading redness of the surrounding skin. The height of reaction is reached at the moment the wheal begins to lose its pallor and turn red. A small red indurated area persists at the point of inoculation

six to twenty-four hours after a positive test, depending on the individual's susceptibility. A positive reaction is apparently more rapid and intense on a perspiring skin than on a dry one. The reaction is less intense or only slight when the scratch or puncture is deep and draws blood. It seems, therefore, that the wheal is due to the entrance of the irritating substance into the lymphatics in the corium and not in the deeper tissues. A negative reaction is without itch or wheal. There is only a redness of the scratch or puncture as the case may be. A slightly positive reaction produces less itching, a small wheal, and an area of redness.

All the forty-eight tests with salivary glands from female mosquitoes (thirty by scratch and eighteen by prick) gave positive reactions. It will be noted that with the scratch method, out of seven diverticula tested only one gave a positive reaction and two slight reactions, while with the prick method the thirteen diverticula (from both sexes) all gave typical positive reactions, except one, which gave a slight reaction. The failure of most diverticula to react by the scratch method was due to a deep scratch, to bleeding, to a very shallow scratch, or to a long interval of time that allowed the serum to dry up between the time of the scratch and the time the diverticulum was inoculated. It was often difficult to pick up a diverticulum heavily loaded with gas bubbles.

OTHER OBSERVATIONS

(*a*) Salivary glands from five female anophelines were allowed to dry on a slide at room temperature (25 to 35° C.) from three to five days. Upon inoculation with a little salt solution, they all produced positive reactions.

(*b*) Diverticula with gas, or with the gas pressed out, gave identical reactions. No difference was noted between the reaction of the abdominal diverticulum and that of the thoracic diverticulum. Diverticulum from the male gave the same reaction as that from the female.

(*c*) Fresh or dried salivary gland rubbed into unabraded skin produced no reaction.

(*d*) Inoculation by prick of one, two, and three lobes of salivary gland from one mosquito produced the smallest wheal with one lobe, and the largest with three lobes. In a repetition of this test the two-lobe inoculum gave the largest wheal.

(*e*) Six individuals were each inoculated twice in an identical manner (prick) with salivary glands from different mosquitoes.

One of them constantly gave a marked reaction with large wheals and areas of redness, two with lesser, and three with slight itching, and tiny wheals and transitory redness around the points of inoculation. Using diverticula, they showed the same varying degrees of reaction obtained with the salivary glands.

(*f*) The reactions obtained from *Anopheles, Culex,* or *Aëdes* showed no difference on comparison.

(*g*) The salivary glands of the male were always much smaller, slenderer, and more fragile than those of the female. This probably accounts for the failure to obtain a good positive reaction for this sex.

(*h*) The parasites, (Sporozoa or fungus, probably not microsporidia) which were not infrequently found in clumps at the base of the salivary glands, gave a typical bite reaction in one test and a slight reaction in another. In the fresh state they appeared as irregular or spherical granular bodies containing a variable number of very refractile "cysts." Under a high magnification, these "cysts" were surrounded by colorless, black, and bluish granules. Stained with Heidenhain's, the parasites were about the size and appearance of amœbæ with vacuoles. Throughout the tests only salivary glands free from these parasites were used. They were not found on the stomach or diverticulum.

(*i*) Positive reactions were observed in a certain number of stomachs, malphigian tubes, œsophaguses, ova, testes, etc.

SUMMARY AND CONCLUSIONS

1. The salivary gland of the mosquito inoculated into the skin produced a typical bite reaction, contrary to Schaudinn's finding.

2. Schaudinn's reaction using the diverticulum was confirmed by the prick method in ten tests with the diverticula from the female mosquito and in three tests with those from the male.

3. The irritation of mosquito bite must, therefore, be due to injection of the salivary-gland secretion or diverticular contents, or both, and not to diverticular origin only.

4. Typical bite reactions were also obtained from parasites (Sporozoa or fungus) and from the other organs; such as, stomach, œsophagus, testes, and ova.

5. Different degrees of susceptibility to the bite were tested and demonstrated in six individuals.

ILLUSTRATIONS

[Microphotographs by C. M. Urbino, Philippine Health Service.]

PLATE 1

FIG. 1. *a*, Thoracic diverticulum with gas; *b*, abdominal diverticulum with gas; *c*, stomach; *d*, Malphigian tubes; *e*, two detached lobes of the salivary gland; about × 55.

2. Salivary gland from *A. vagus* Donitz with eight lobes and a cluster of parasites at the base; about × 160.

1

2

PLATE 1.

MALARIA TRANSMISSION IN THE PHILIPPINES, III [1]

DENSITY AND INFECTIVE DENSITY OF ANOPHELES FUNESTUS GILES

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The present paper is a continuation of the preceding two articles and is based on certain data compiled from observations that began in September, 1927, in La Mesa camp of the Novaliches water project and extended during the following two years to seven other camps and two barrios far from, and independent of, the project. An attempt will be made to show the significance of density in the transmission of malaria without considering the suitable human-carrier factors. About 22,000 *Anopheles funestus* Giles were caught, mostly by trapping, and were dissected. With these were 298 infected mosquitoes found in six out of ten places, as follows: In South Portal camp 218 positive mosquitoes were caught; in North Portal, 26; in La Mesa, 32; in Atlantic, Gulf, and Pacific Company camp, 13; in Tungkong Manga, 7; and in San Francisco del Monte, 2 (oöcysts only). No positive mosquitoes were caught in Novaliches Barrio, Bigti, Santo Cristo, or Alinsangan camps.

The traps used were of standard dimensions and the time employed by the catcher was practically the same in all areas. Approximately the same number of hours was also used in catching mosquitoes without traps. The densities obtained through these collections are only approximate, but the duration and regularity of observation are considered sufficiently adequate to counterbalance the errors.

The appended tables give the catches of *A. funestus* in all areas with the results of dissection, densities for the positive and negative months, and densities in four negative places. Infective (sporozoite rate) densities are expressed as one for every so many mosquitoes dissected by individual months and as monthly averages during each year. Table 7 is a summary

[1] From the field laboratory, division of malaria control, Philippine Health Service, Tungkong Manga, Bulacan.

of findings in five places, by years, where sporozoites were discovered, giving the average monthly and infective densities by years, and the average densities for negative months, if any, to compare with the average densities of positive months. Table 6 shows the catches in four areas where no infected *funestus* were found.

TABLE 1.—*Catches and findings in South Portal.*

Year and month.	Number caught.	Positives.			Infective (sporozoite) density. One in—
		Stomach.	Salivary gland.	Total infected.	
1927					
December	234	6	2	8	177
1928					
January	723	9	4	13	181
February	201	3	3	6	67
March	567	7	6	13	95
April	498	3	8	11	62
May	562	16	17	33	33
June	469	6	11	17	43
July	735	23	10	33	73
August	490	16	7	23	70
September	371	8	7	15	53
October	671	9	2	11	335
November	255	3	2	5	127
December	223	4	6	10	37
Total	5,765	107	83	190	
Average catch per positive month (density), 1928	480				
Average monthly infective density					[a] 69
1929					
January	93		1	1	93
February	65	2		2	
March	90	3	4	7	23
April	170	1	1	2	170
May	124	2	2	4	62
June	313	2		2	
July	148				
August	81	1		1	
September	43				
October	29				
November	47				
December	57	1		1	
Total	[b] 993	12	8	20	
Average catch per positive month (density), 1929	124				
Average catch per negative month (density)	67				
Average monthly infective density					[a] 124

[a] Computed on catches during positive (stomach and salivary gland) months only.

[b] Positive months only. December, 1927, to February, 1928, inclusive, by exposure. Trap used since March, 1928.

COMMENTS

South Portal (Table 1) was by far the most malarious (more transmission) of the six places, judging by the mosquito infection. In this camp, the year 1928 was more malarious than 1929, there having been not only more *funestus* but fewer bites were necessary for infection. The average monthly density and the infective density were 480, and 1 in 69, respectively, in 1928, as compared with 124, and 1 in 124, respectively, in 1929. Within the average twenty-three catching days per month, the susceptible human bait in the trap had seven chances monthly of becoming infected if all the mosquitoes bit him, or an average of almost one infective bite every three days during 1928. In 1929, his chance was one infective bite in twenty-three days; in December, 1927, two infective bites in twenty-three days.

At North Portal (Table 2) with its monthly density of 412, and infective density of 1 in 515, in 1928, it would have required the bites of all the mosquitoes coming into the trap for twenty-nine days to assure an infective one being included, while in 1929, with 833, and 1 in 1,250, as monthly and infective densities, respectively, it would have required thirty-five days before infection could have been received.

La Mesa (Table 3) was more malarious in 1928 than in 1927, in spite of a larger number (more than three times) of *funestus* in 1927. The infective density of 1 in 400 and the monthly density of 500 in 1927 would only give a little over one infective bite during twenty-three catching days, while the lower density of 120 in 1928 would give more than two infective bites (the infective density being 1 in 52). The duration of observations in the other places does not permit comparison of infection of one year with another, but a comparison of one place with another shows again the rôle of density in the amount of malaria transmission.

In 1929, the average density during the positive months (January to May) in Tungkong Manga was 846 for a month of twenty-three catching days. The infective density was 1 in 1,411, so that it would have required an exposure of thirty-nine days before an infective bite could have been received. This is in accord with James's [2] statement that "numerous anophelines

[2] Malaria at Home and Abroad. John Bale, Sons and Danielsson, Ltd., London (1920) 13.

TABLE 2.—*Catches and findings in North Portal.*

Year and month.	Number caught.	Positives.			Infective (sporozoite) density. One in—
		Stomach.	Salivary gland.	Total infected.	
1927					
December	8	1		1	
1928					
January	30	3		3	
February	105				
March	0				
April	0				
May	7				
June	0				
July	0				
August	0				
September	110		1	1	110
October	939	12	2	14	469
November	209	1		1	
December	771	1	1	2	771
Total	[a]2,059	17	4	21	
Average catch per positive month (density)	412				
Average catch per negative month (density)	56				
Average monthly infective density					[b]515
1929					
January	1,307	1	1	2	1,307
February	620	1		1	
March	572		1	1	572
April	366				
May	68				
June	46				
July	26				
August	10				
September	5				
Total	[a]2,499	2	2	4	
Average catch per positive month (density)	833				
Average catch per negative month (density)	87				
Average monthly infective density					[b]1,250

[a] Positive months only.

[b] Based on total catches in positive months. Trap used since September, 1928.

of a species which is an efficient carrier are associated with little or no malaria," and with Gill's [3] reference to "anopheles *sine* malaria, one instance of which is the large measure of 'control,' achieved over malaria in Italy by the method of 'bonification' in spite of the fact that this measure has actually led, in some instances, to increased prevalence of anophelines." Had the density in Tungkong Manga prevailed in La Mesa (com-

[3] Trans. 7th Cong. Far Eastern Assoc. Trop. Med. 2 (1927) 630.

TABLE 3.—*Catches and findings in La Mesa.*

Year and month.	Number caught.	Positives.			Infective (sporozoite) density. One in—
		Stomach.	Salivary gland.	Total infected.	
1927					
September	669		1	1	669
October	473	3		3	
November	512	4	4	8	128
December	346	6		6	
Total	2,000	13	5	18	
Average catch per month	500				
Average monthly infective density					400
1928					
January	116	1	3	4	39
February	61				
March	227	5	4	9	57
April	0				
May	7				
June	0				
July	0				
August	0				
September	18	1		1	
Total	[a] 361	7	7	14	
Average catch per positive month (density)	120				
Average catch per negative month (density)	34				
Average monthly infective density	52				

[a] Positive months only. Catches by exposure.

pare with May, 1928, South Portal) during January, February, March, and April, 1928, with an infective density of 1 in 52, the rate would have meant sixteen infections in twenty-three days; in which case only a little over one day of exposure would have been required to cause one infection. This would have resulted in an explosive epidemic that would probably have disappeared rapidly from May till October (average density 6 per month). Conversely, had the monthly infective density of Tungkong Manga, 1 in 1,411, occurred in La Mesa, with its monthly density of 120, it would have required two hundred eighty-one days of exposure before a positive bite could have been contracted, so that there would have been no malaria at all in the locality (compare with 1929, Tungkong Manga).

The fluctuation of individual monthly density and the corresponding infective number (the latter due to the number of suitable human carriers, whose movements and accessibility to the vector could not possibly be under control) is interesting

TABLE 4.—*Catches and findings in San Francisco del Monte.*

Year and month.	Number caught.	Positives.		
		Stomach.	Salivary gland.	Total infected.
1928				
June	2			
July	1			
August	5			
September	32			
October	108	2		2
November	69			
December	80			
Total	[a] 108	2		2
Average catch per positive month (density)	108			
Average catch per negative month (density)	32			
1929				
January	108			
February	29			
March	4			
April	8			
May				
June				
July	1			
August	1			
Total	151			
Average monthly catch (density)	25			

[a] Positive month only (October). Trap used from September, 1928.

and explains how easily a person may contract the disease during a very short visit to a malarious place. Take, for example, South Portal in May, 1928, when a trap density of 562 with an infective density of 1 in 33 was capable of seventeen infective bites in twenty-three catching days. During the month, one could easily have contracted the disease in a little over one night's sleep in the camp. Yet, in terms of the infection rate, the usual way of expressing malaria in numbers of mosquitoes, only 3 per cent of them had sporozoites in their salivary glands capable, at the time, of transmitting the disease; certainly a low figure by itself if one is to receive only one bite. But since, in nature, an exposed individual receives several or many bites during a single night, his chances of infection must rise in proportion to the number of bites he receives. To produce an infection for example, thirty-three individual mosquito bites would not be too many or too noticeable a number to be received in, say, two nights during slumber. The percentage

method of expressing malaria in mosquitoes seems to have led experienced students to explain the very high incidence of malaria in man by assuming that the vector bites only in the house, and that once infected it stays in the same house, or that if it leaves it usually returns, or by the findings (experimental or epidemiological) that an infective anopheline can infect several people in one night or many in several consecutive nights (James).[4] A similar argument was put forth by Swellengrebel[5] of the Malaria Commission of the League of Nations in the discussion of the subject, "Where does *A. maculipennis* infect man?" to prove that it (*maculipennis*) bites in the house and not in the open. He says,

> Even under extremely favourable conditions, the number of infected *A. maculipennis* is so small that the chances of being infected by anopheles in the open seem to be infinitesimal, even if this insect were in the habit of biting in the open, which is generally supposed not to be the case. On the other hand, if we suppose that at least a portion of the anophelines regularly visiting houses remain there sufficiently long to become infective after having become infected with malaria parasites, this would explain not only human infections, even with a small parasite index among the anophelines but also the house infection so often observed. This house infection can hardly be explained by random infection.

. . . His figures showing the greater prevalence of infective mosquitoes in the houses as compared with the stables to prove his contention are as follows:

> In winter (Sella in Fumicino: October-December, 1918, 3.8–4.6 per cent infected in houses, 0.49–0.85 per cent in stables); (Swellengrebel, Amsterdam, October-December, 1920, 4.99 per cent infected in houses, 0.66 per cent in stables). But in summer this may be different (Sella, June-September, 1919, 0.5–3.3 per cent in houses; 0.27–2.00 per cent in stables).

These figures are not significant, unless it is possible to show that the stable rates of infection were based only on the numbers of *maculipennis* actually concerned in the malaria transmission in man, but resting in the stable, and that the rates were not influenced by the numerous anophelines in the stable that fed solely on animals. A corrective factor based on precipitin test should have been mentioned. King[6] observed that a high mosquito density (575 bites during the season) offsets a low infec-

[4] See reference, footnote 2.

[5] Report on its tour of investigation in certain European countries in 1924. Geneva (March, 1925) 178.

[6] Southern Med. Journ. 17 (1924) 596–597.

tion rate (0.107 per cent) and accounts for the prevalence of malaria. It is believed that a study of the densities and infective densities in different sections or in houses of a locality over an adequate period of time will explain house infection more satisfactorily, as only then can the theory of many human infections from a single mosquito (a rather difficult task to demonstrate directly in nature, particularly if the vector is wild, although understandable epidemiologically) be proved with reasonable scientific certainty. In his summary (p. 183), however, Swellengrebel said:

> The evidence that man is infected outside his habitations (in the wider sense of the word) is still insufficient, but strong enough to warrant further enquiry.

He mentioned that during their visit to Fumicino (p. 180) Grassi emphasized the discordance between the high malaria incidence and the low number of anophelines in the house and set forth the following practical question:

> If the number of anophelines in the immediate surrounding of man has so little to do with the incidence of malaria, is this not an indication that if once anophelines are present in a certain minimum quantity, other factors influencing the incidence of malaria tend to become of such predominating importance that it matters little whether the initial number of anophelines is maintained or multiplied tenfold? If this, or anything like it, were true, any attempt to diminish the malaria-incidence by reduction of the number of anophelines will be useless, unless the reduction reaches this hypothetical minimum.

The last question is in accord with Ross [7] and explains the excellent results of Watson's antilarval measures in many of his projects in Malaya, the water-cistern control in Palestine, particularly Jerusalem, mosquito control in the United States, and Hackett's projects in Italy. It is also clear that an initial hypothetical anopheline density and infective density in one locality capable of inflicting an infective bite every two or three days (compare with May, 1928, South Portal) can be maintained or multiplied tenfold and still infect 100 per cent of the exposed and susceptible individuals within a short period of time because the number of new cases will appear rapidly and, therefore, outnumber the recoveries. But a density and infective density of one infective bite in one month as an initial minimum hypo-

[7] "That if the number of malaria-bearing *Anophelines* is below a certain figure that limit (fixed limit of malaria) is zero."—The Prevention of Malaria (1911) Sec. 28.

thetical number in another locality (Tungkong Manga, 1929), if only maintained, cannot possibly infect a large percentage of the people within a short time because the number of new cases are too few and far apart to outnumber the recoveries. To infect 100 per cent it would be necessary to multiply the initial density many times over.

The summaries given at the end of the present paper are believed sufficient answer to the practical question quoted from Swellengrebel. The hypothetical number must be, according to the data presented, not only variable in the same place at different periods, but must also differ in different localities, which accounts for the successes and failures of the mosquito-control measures that have always been the cause of misunderstanding between the Malaria Commission and the antimosquito enthusiasts, as evidenced in their conclusion written by Swellengrebel [8] (p. 189) as follows:

> Although during our tour we have seen many instances of anti-larval or anti-adult measures, there was not one of them in which the efficiency of the measure had been proved by its influence on the prevalence of malaria. This does not mean that there had not been such an influence, although in many instances this was probably so, but that the methods to collect the necessary statistical material had been inadequate.

On page 174 he says:

> We have tried to form a judgment on the effect of the anti-larval measures demonstrated to us, not by the reduction of the malaria rate (because (1) this reduction usually could not be demonstrated, owing to the absence of reliable statistical material; (2) it often coincided with a reduction in other places where no such measures were taken; (3) this measure was never taken without others, notably quininisations, the effect of the two being difficult to distinguish) but by the prevalence of larvæ in the breeding places and of adult anophelines in houses especially in stables.

In this instance the conclusion is unavoidable that the Malaria Commission of the League of Nations erred in undertaking to form a judgment (on the influence of antilarval measures in particular places where malaria has been reduced) based on the prevalence of larvæ in the breeding places and on adults in houses and stables at the time of their visit, when data on the prevalence of both larvæ and adults (which should have been measured by the same standard used by the commission) before the control was instituted, were either not available or utilized for the purpose of comparison.

[8] See reference, footnote 5.

TABLE 5.—*Catches and findings in Atlantic, Gulf, and Pacific Company and Tungkong Manga.*

ATLANTIC, GULF, AND PACIFIC COMPANY.

Year and month.	Number caught.	Positives.			Infective (sporozoite) density. One in—
		Stomach.	Salivary gland.	Total infected.	
1928					
January	311	7	3	10	104
February	29	3	----	3	----
March	12	----	----	----	----
April	7	----	----	----	----
Total	[a] 340	10	3	13	----
Average catch per positive month (density)	170	----	----	----	----
Average catch per negative month (density)	10	----	----	----	----
Average monthly infective density	----	----	----	----	113

TUNGKONG MANGA.

1928					
December	273	----	----	----	----
1929					
January	1,367	1	----	1	----
February	849	2	1	3	849
March	917	1	----	1	----
April	1,086	----	1	1	1,086
May	13	----	1	1	13
June	39	----	----	----	----
July	18	----	----	----	----
August	4	----	----	----	----
September	1	----	----	----	----
October	20	----	----	----	----
November	166	----	----	----	----
December	282	----	----	----	----
Total	[a] 4,232	4	3	7	----
Average catch per positive month (density)	846	----	----	----	----
Average catch per negative month (density)	100	----	----	----	----
Average monthly infective density	----	----	----	----	1,411

[a] Total for positive months only. A, G, & P. Co. by exposure. Trap used in Tungkong Manga since June, 1929.

The unaccountable marked drop in *A. funestus* densities in 1929 in North Portal and Tungkong Manga (February in the former and May in the latter), two distant places (Tables 3 and 5), is significant and explains the sudden diminution or disappearance of transmission in certain localities, which are often attributed to control measures. It would not be surprising if some of the places investigated by the commission were instances

of this nature. On the other hand, the high density maintained in South Portal in 1928 is most favorable for continuous or hyperendemic malaria which, as has been experienced, was not amenable to larval control, while the monthly and infective densities in 1929 (124, and 1 in 124, respectively) might have easily been affected by larval destruction.

It is also clear how a small number of *A. funestus* (120 per month of twenty-three catching days in La Mesa in 1928 or 5 per night) can produce considerable malaria (infective density, 1 in 52). A similar condition might have prevailed at Ennur as cited by James,[8] as it would have required three experienced observers four days to catch the sixty mosquitoes.

The data presented show clearly that a quantitative measure alone of the transmitting species, no matter how careful and systematic it is, does not give the same amount of necessary information that their systematic collection and examination for sporozoites do on the epidemiology of malaria, when it is considered that the factors of suitable human carriers and susceptibles are continuously variable. In case the vectors bite animals with frequency, the density should be corrected by using a precipitin-test factor. Mosquito density in a locality at a given period is of importance only when the infective number in the same locality during that period is known. With these two adequate data available, the amount of malaria in a susceptible community is directly proportional to the adult density of the carrying species. The procedure for these determinations seems simpler, and the results scientifically more accurate and direct because only mosquitoes are dealt with, dispensing with the uncontrolled human-carrier movement and the still more difficult work of determining who and how many are the carriers and for how long a period they will be suitable mosquito infectors, and the equally difficult task of differentiating between the new attack and the relapse in the measurement of malaria in man.

If the catches in the four negative places (Table 6) could be considered sufficient, the low density and probably a 1 to a very high figure of infective density (for example, 1 in 2,000 or more) explain why evidence of malaria transmission was not

[8] "Thus at Ennur in Madras where most of the inhabitants suffered from malaria, the infecting species of anopheline was so rare that three experienced observers were occupied for several days in catching about sixty specimens." See reference, footnote 2.

observed and new cases were not as prevalent in them as in the other camps with similar topography and mosquito fauna.

TABLE 6.—*Catches by exposure in four negative places.*

Place.	Year and month.	Number caught.
	1927	
Novaliches	December	2
	1928	
Do	January	122
Do	February	150
Do	March	274
Do	April	39
Total		585
Average per month (density)		117
	1929	
Santo Cristo	May	13
Do	June	11
Do	July	16
Do	August	0
Do	September	1
Do	October	2
Do	November	100
Do	December	123
Total		266
Average per month (density)		33
	1929	
Bigti	October	2
Do	November	107
Do	December	82
Total		191
Average per month (density)		64
	1929	
Alinsangan	November	23
Do	December	18
Total		41
Average per month (density)		20

SUMMARY

1. Data collected from ten places consisting of dissections of about 22,000 *Anopheles funestus* from September, 1927, to December, 1929, inclusive, show monthly (twenty-three catching days) and yearly variations in densities in different localities and in different periods of the same locality as measured by systematic catches by trapping with human bait or by exposure.

TABLE 7.—*Summary showing average monthly densities, positive and negative months, and infective numbers in five places where sporozoites were found by dissection.*

Place.	Year.	Monthly density positive months.	Monthly density negative months.	Average monthly infective number. One in—
South Portal	1927	234		177
Do	1928	480		69
Do	1929	124	67	124
La Mesa	1927	500		400
Do	1928	120	34	52
North Portal	1928	412	56	515
Do	1929	833	87	1,250
Atlantic, Gulf, and Pacific Company	1928	170	10	113
Tungkong Manga	1929	846	75	1,411

2. The infective density or number (sporozoite rate) varied in different places, and in the same place in different periods due to variations in the ever changing human-carrier factor.

3. Much malaria with few transmitters and vice versa exist and can be explained by a knowledge of the density and the infective number of the place at the time.

4. Natural unexplained marked decline in density has been observed in two places and explains the sudden disappearance of transmission in certain uncontrolled localities, which are often attributed to antimalarial measures in controlled areas.

5. The numerical prevalence of the transmitting species alone means little in the epidemiology of malaria, neither can a known density in one locality be utilized for comparative purposes in another. However, the direct relationship of the vector's density to malaria transmission in a locality at a certain period, when the corresponding infective number for that locality and period is known, has been shown to operate in nature.

6. A study of the densities and sporozoite rates of the transmitting species in several localities of the Novaliches water project over an extended period has revealed at least some of the fundamental causes of the different behaviors of malaria incidence that were formerly obscure.

7. Important documents have been quoted and discussed in the light of the present findings. They show that opinions on numerical anopheline prevalence and malaria incidence have apparently been based on inadequate field data.

FRESH-WATER SPONGES OF THE PHILIPPINE ISLANDS

By N. Gist Gee

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FOUR TEXT FIGURES

Very little has as yet been done toward the study of the fresh-water sponges of the Philippine Islands. Doubtless, a little time spent by collectors in examining the lakes, ponds, and streams of the Islands would yield a rich supply of interesting new materials. So far as I can learn only four species of this group have up to date been recorded from the Islands and all of them were described as new to science.

The first species is recorded by W. Weltner,[1] who describes *Ephydatia fortis* as a new sponge and gives the following note concerning its occurrence and collector: "Libmananfluss auf Luzon, Museum Berlin, Jagor leg." The type specimen of this sponge is in the Berlin Museum.

The other species were described by Annandale from material in the United States National Museum. He[2] described two new species, *Spongilla philippinensis* and *Spongilla clementis*, which were collected by Mary Strong Clemens in January, 1907, at Camp Keithley, Lake Lanao, Mindanao, at an elevation of 2,250 feet. In another paper Annandale[3] again reports upon Philippine fresh-water sponges. Paul Bartsch collected some specimens of fresh-water sponges from Vicars Landing, Lake Lanao, Mindanao, in May, 1908. These were determined by Annandale to be *S. philippinensis;* this makes a second locality in Lake Lanao in which this sponge has been found.

Other fresh-water sponges were collected by Hugh M. Smith, of the expedition of the Bureau of Fisheries steamer *Albatross*, December 26, 1907, from Taal Lake, on the east side of Taal Island, Luzon. Annandale called this sponge a new species and named it *Spongilla microsclerifera.*

[1] Spongillidenstudien III, Archiv fur Naturg. 1 (1895) 141.
[2] Proc. U. S. Nat. Mus. 36 (1909) 629–632.
[3] Proc. U. S. Nat. Mus. 37 (1909) 131, 132.

The type specimens of the last three sponges are in the United States National Museum.

Without doubt there are other fresh-water sponges to be found in the Philippine Islands and the writer would be pleased to receive specimens for study. They may be dried in the shade, wrapped in soft paper, and then sent by post in small tin boxes or in strong, light, wooden cigar boxes. Specimens should, if possible, contain gemmules, but even when without them they should be gathered. A former correspondent, now deceased, wrote of the great abundance of these sponges on the fishing traps in the waters near Los Baños, but he unfortunately did not send me specimens of these.

SPONGILLA PHILIPPINENSIS Annandale, 1909. Text fig. 1.

Historical statement.—This sponge was collected in January, 1907, by Mary Strong Clemens, at Camp Keithley, Lake Lanao, Mindanao, Philippine Islands, at an altitude of 2,250 feet. It was sent by the United States National Museum, together with other sponges, to Dr. N. Annandale, of the Calcutta Museum, for identification. His illustrated description was published in 1909.[4] Since the very small bit of this sponge, which the United States National Museum has kindly given me, contains no gemmules and is too small to give any idea of the structure of the sponge, I shall quote in full Annandale's original detailed description.

Habitat.—Paul Bartsch collected additional specimens of this species at Vicars Landing in the same lake in May, 1908. They were taken in shallow water and were attached to the submerged drift around the edge of the lake.

General characteristics.—"The sponge has evidently formed a sheet of considerable size adherent to some solid body, but has been broken into small pieces in the type specimens, which are about one centimeter thick. The surface is smooth with numerous oscula level with it. There is no trace of branches."

Color.—"Externally the sponge appears to have been bright green in color, but the basal parts are yellowish." It is gray in alcohol.

Structure.—"The texture is light and friable, by no means elastic. In vertical section both radiating and transverse fibers are visible to the naked eye and the sponge has a distinctly reticulate appearance, although the vertical interspaces are

[4] Proc. U. S. Nat. Mus. 36 (1909) 629–631.

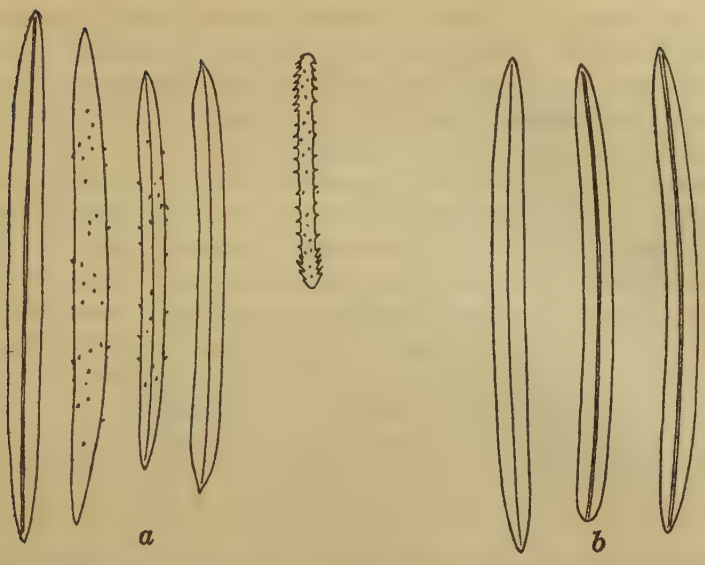

FIG. 1. *Spongilla philippinensis* Annandale. *a*, Showing both the smooth and the spined skeleton spicules; also one gemmule spicule (after Annandale); *b*, smooth skeleton spicules with axial canals clearly showing. (Drawing by C. F. Wu.)

much more conspicuous than the horizontal ones. Wide circular canals penetrate the sponge in a course parallel to the base. Comparatively little spongin is present. Under the microscope it is evident that the radiating fibers are much more coherent and regular than the transverse ones. On the external surface of the sponge a network of the horizontal spicules can be distinguished. There is a delicate, basal structureless membrane. The ectodermal membrane has perished."

Skeleton spicules.—"The skeleton spicules measure 0.174 mm. to 0.278 mm. in length and on an average 0.021 mm. in greatest transverse diameter. They are very sharply pointed at both ends, straight or nearly so, smooth or somewhat sparsely covered with extremely minute projections, the ends being always smooth."

I find these spicules to range between 229 and 271 μ in length and between 14 to 20 μ in diameter. In the slides that I have examined I have found no spined spicules at all.

Flesh spicules.—There are no flesh spicules.

Gemmules.—"There are few gemmules, those that exist occurring singly in the substance of the sponge and being free. They have a blackish color, are spherical, measuring on an average 0.609 mm. in diameter. Each is provided with a single

aperture, to which a short, straight, rather stout foraminal tubule is attached. The inner chitinous coat is rather thin, but the granular coat is well developed and contains many spicules, which are arranged horizontally or nearly so as a rule, but sometimes to a slight extent tangentially."

Gemmule spicules.—"The gemmule spicules are very variable in length, measuring from 0.0798 mm. to 0.122 mm. in length and about 0.0031 mm. in transverse diameter. They are cylindrical, straight or nearly so, armed with somewhat irregular spines, which are often slightly retroverted at the two ends. Sometimes there is a single straight spine at either end, but often the spicule ends abruptly and is surrounded by a ring of spines in such a way as to suggest a rudimentary rotule."

Type.—The type is preserved in the collection of the United States National Museum in Washington. I have a small, gemmuleless specimen (No. 54337) from that museum in my collection.

Distribution.—*Spongilla philippinensis* has so far been found only in Lake Lanao, but a closely related form, *S. sceptrioides*, has been described from New South Wales and Queensland, Australia.

Remarks.—From the descriptions and illustrations of *S. philippinensis* and *S. sceptrioides* given by Annandale, it seems that the spicules of these two sponges are very similar and I doubt very much that they are both entitled to separate specific rank. It is very desirable that new material of both of these sponges be collected for further comparison before a final decision is reached. *S. philippinensis* is also related to *S. alba* but is readily distinguished from it "by having minutely spined megascleres, green corpuscles, slender gemmule spicules with short spines and no free microscleres."

Concerning the specimens collected by Bartsch in May, 1908, Annandale writes that while no gemmules were present, the sponges were full of embryos. "The embryos lie in the interstices of the skeleton and have no protecting membrane as is the case in some oriental species (Records of Indian Mus., Vol. 1, p. 269 (1907). They are so numerous that in preparations made by boiling pieces of the sponge in nitric acid their minute immature skeleton spicules are present in sufficient numbers to appear to be a feature of the species and might easily be mistaken for free microscleres. True flesh spicules are, however, absent."

SPONGILLA CLEMENTIS Annandale, 1909. Text fig. 2.

Historical statement.—In January, 1907, Mary Strong Clemens collected this species at Camp Keithley, Lake Lanao, Mindanao, Philippine Islands. The altitude of the lake is 2,250 feet. This sponge was described and illustrated by Annandale.[5] Annandale described a similar sponge from Tali Fu, Yunnan, China, calling it at first *Spongilla yunnanensis*[6] but later,[7] he corrected this and designated that sponge also as *S. clementis*. The same author, in 1916, also described the same species from Lake Biwa, Japan.[8] The description that follows is based upon Annandale's descriptions of the several forms examined by him and my observations upon a small specimen of the original Philippine material kindly furnished me by the United States National Museum, a small bit of the Tali Fu sponge kindly provided by the Indian Museum, and a splendid series of specimens from Japan kindly given me by Doctor Kawamura, of the Biological Station at Otsu.

Habitat.—In Lake Lanao this sponge was found growing in close association with *Spongilla philippinensis*. In Yunnan it was found growing on small stones in the lake where it formed small rounded masses. In Lake Biwa it grew in three quite distinct phases: (1) It formed flat crusts of irregular outline usually less than 10 millimeters in thickness. (2) This phase also formed crusts, but was more massive than the first and at times developed "thick ramifying horizontal branches." Both of these phases were found growing on the pillars of bridges and piers and other similar supports, and sometimes covered considerable areas. (3) The third phase differs decidedly from the other two; it formed "compact, ovoid, spherical, irregularly massive or pedunculate masses." These masses grew on certain living mollusks or were found on stones, sticks, or lying free on the clean, sandy bottom of the lake in deep water.

General characteristics.—"In general appearance and color, this sponge, judging from the dry specimens, closely resembles *Spongilla philippinensis*, but the surface is usually covered with a network of deep, broad furrows which separate small elevated areas of more or less circular form. The oscula occur on these elevated areas and are large and numerous. Prob-

[5] Proc. U. S. Nat. Mus. 36 (1909) 631–632, fig. 4.
[6] Rec. Indian Mus. 5 (1910) 197.
[7] Mem. Asiatic Soc. Bengal. 6 (1918) 201.
[8] Journ. Coll. Sci. Tokyo 39 (1916) 7.

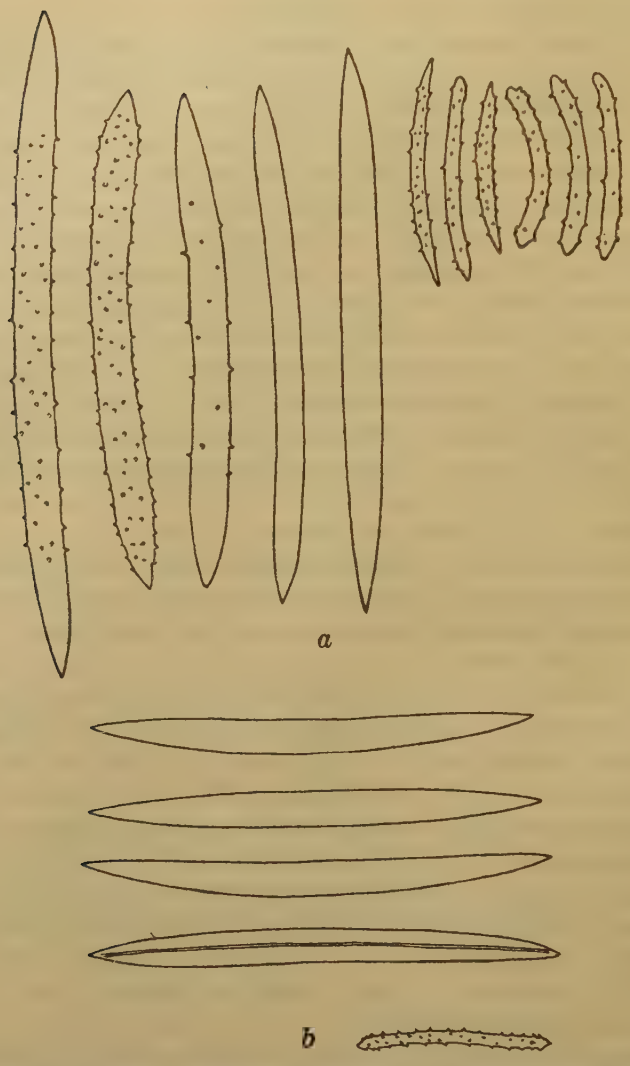

FIG. 2. *Spongilla clementis* Annandale. *a*, Spined and smooth skeleton spicules from specimens from Lake Biwa, Japan; the smaller spicules show the variations in gemmule spicules (after Annandale); *b*, skeleton and gemmule spicules of specimen from Lake Lanao, Mindanao; only smooth skeleton spicules were found (after Annandale).

ably in the fresh sponge the furrows are roofed in by the ectodermal membrane."

Color.—The color of the Philippine specimen of *S. clementis* was quite similar to that of *S. philippinensis*, green on the surface and yellowish underneath. The China representative of

this species was of a dull greenish color when growing. Annandale describes the colors of the various specimens of this sponge from Japan as "leaf green, grayish or yellowish, . . . tinged with green, but the color never extends to the interior, . . . grayish or whitish." The majority of our specimens (dry) from Japan are a light brown or straw color; a few are of a grayish color.

Structure.—"In vertical section the transverse fibers of the skeleton of this species from the Philippine Islands are seen to be stouter and more regular than those of *S. philippinensis,* being hardly inferior to the radiating fibers in these respects, so that the skeleton forms a much more regular network than is the case in the other sponge."

There is a good deal of variation in the consistency of the Japan sponges. Some of them have transverse fibers strong enough to make them quite firm and hard, while others are soft and easily crumbled. In the Philippine representatives of this species "there is a stout chitinous membrane, which sends bunches of hollow, root-like processes downwards at intervals. These do not appear to be in any way connected with the primary skeleton fibers. There are numerous scattered skeleton spicules in the basal membrane."

In the Japan forms, the oscula are usually numerous, large, and round and open upon the smooth surface of the sponge. Slight elevations or ridges may sometimes be formed around the oscula, or in some phases they may even develop crater-like cones.

Skeleton spicules.—Here again it is difficult to cover all variations in skeleton spicules in one general description. My specimens of both the Tali Fu and the Lake Biwa sponges have only smooth spicules in their skeletons. The Philippine sponge has a large majority of its spicules with spines, although the number of spines may vary from a very few small ones, which appear to be only granulations, to a rare spicule now and then that is thickly studded all over, except at the tips, which has prominent spines (fig. 3).

The spicules of the Japan forms closely resemble those of the Yunnan specimen, and I am of the opinion that these two species more closely resemble the form described by Annandale as *S. clementis,* even though I evidently have a bit of what seems to be the original Philippine material from the United States

National Museum from which Annandale described this species. The resemblance between this Philippine sponge, *S. clementis*, and the one which Annandale describes as *S. sceptrioides* in the same paper is quite close. I think that additional material bearing gemmules will have to be secured before a final decision as to the identity of these several specimens can be reached.

The spicules of all of them are gently curved and average around 255 μ in length. There is probably more variation in the thickness of the spicules, the range being from 12 μ to over 20 μ in some of them. The China and Japan specimens are rather abruptly and bluntly pointed, while the Philippine specimen is more sharply and gradually pointed.

Flesh spicules.—There are no flesh spicules.

Gemmules.—Annandale found no gemmules in the Yunnan specimen. He found very few gemmules in the Japanese material; and I have not succeeded, after a careful and prolonged search, in finding even a single gemmule in all of my numerous specimens of this species representing all three phases from Lake Biwa. The gemmules are evidently extremely rare. Those observed by Annandale were at the base of the sponge attached to the basal membrane, and they very likely are, most often, left on the support when the sponge is removed. Annandale says concerning the Philippine sponge, "There are very few gemmules indeed. They occur singly in the basal membrane and are apparently closely adherent to the support of the sponge. Each measures about 0.325 mm. in diameter (the shape being spherical) and is provided with a single straight foraminal tubule on the summit. The granular coat is feebly developed, but there is a strong outer chitinous coat in continuity with the basal membrane. The gemmule spicules lie in this coat parallel to the surface of the gemmule but crossing one another at all angles."

Gemmule spicules.—"The gemmule spicules are slender, cylindrical, nearly straight. In the middle they bear minute irregular projections, which only take the form of actual spines towards the two ends. Each end terminates in a stout, straight spine, surrounded by a row of smaller spines at right angles to it. None of the spines are retroverted." They are about one-third of the length of the skeleton spicules.

Type.—The type is in the United States National Museum, Washington, D. C. I have a small specimen from that mu-

seum labeled as *S. clementis,* but it differs somewhat from the typical form of *S. clementis* as originally described and appears to be very similar to *S. philippinensis.*

Distribution.—This species was described from Lake Lanao, Philippine Islands. Later it was collected in Tali Fu, Yunnan, China, and then in great abundance and in three distinct phases, in Lake Biwa, Japan, and in the settling tanks of the waterworks of the neighboring city of Kyoto. The water supply of Kyoto comes from Lake Biwa.

Remarks.—Annandale calls attention to the following points in which *S. clementis* differs from *S. philippinensis.* It has shorter and smoother skeleton spicules; it has a more regular skeleton; it has a thicker basal membrane; it has adherent gemmules with their ill-developed granular coat. I would add, from Annandale's description, another difference; namely, none of its gemmule spicules have retroverted spines.

SPONGILLA MICROSCLERIFERA Annandale, 1909. Text fig. 3.

Historical statement.—This sponge was collected by Dr. H. M. Smith from Lake Taal on the east side of Taal Island, Luzon, December 26, 1907. It was described, without illustrations, by Annandale.[9] The United States National Museum has kindly made available to me a small bit of this sponge, but as it is so small and there are no gemmules in it I shall quote parts of the original description, adding my observations where I have material to justify this; that is, on the skeleton and the flesh spicules.

Habitat.—The sponge was reported as being abundant around the shores of the lake and as having been washed up by the waves on to the shore in large quantities during storms. The specimens examined by Annandale "appear to have coated both surfaces of leaves, which have perished and almost disappeared."

General characteristics.—The sponge is "light, fragile, tomentose, . . . apparently without branches and of no great thickness."

Color.—It is "of a dirty white color in dry specimen." In alcohol the color of my small specimen is a very light brown.

Structure.—"Skeleton practically devoid of spongin but forming a close and almost regular reticulation in which the radiating and transverse fibers are of approximately equal diameter. The

[9] Proc. U. S. Nat. Mus. 37 (1909) 131–132.

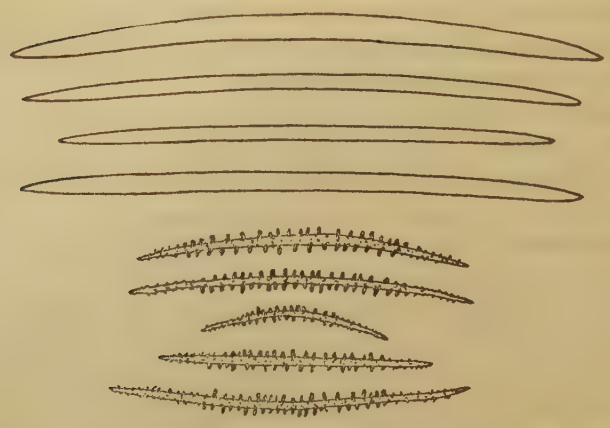

FIG. 3. *Spongilla microsclerifera* Annandale. Skeleton and fresh spicules. No gemmule spicules were found in my specimens. (Drawing by C. F. Wu.)

free microscleres are extraordinarily abundant in the interstices of the skeleton."

Skeleton spicules.—The skeleton spicules are smooth, slightly curved, rather slender and of nearly uniform diameter except near the ends where they become abruptly sharp-pointed. Scattered among the others in our preparations are a few heavier spicules which I suppose belong to some other sponge.

	Annandale.	Gee.
Length of spicule, μ	254–365	229–310
Diameter of spicule, μ	8.3	6–9

Flesh spicules.—The flesh spicules are very abundant. They are very variable in length and are extremely thin. As a rule they are decidedly curved and it is very rare that a straight one can be found. In the center where the spicule is thickest, the spines are heaviest and often end in rounded knobs; toward the ends of the spicules, where they become extremely tenuous, the spines are very minute and are sharper pointed. My measurements vary only very slightly from those of Annandale.

	Annandale.	Gee.
Length of spicule, μ	59.3–124.5	80–127
Diameter in thickest part, μ	1.03–2.07	1.50–3

Gemmules.—"Gemmules few, free, small, spherical, without a foraminal tubule, with a thick granular coat, in which the spicules are arranged tangentially and horizontally in an irregular manner. Diameter of gemmule 0.35–0.49 mm."

Gemmule spicules.—"Gemmule spicules slender, cylindrical, nearly straight, bluntly pointed at the ends, irregularly covered with short, sharp spines, which are more numerous at the extremities, at which they are usually directed backward, than in the middle."

Type.—The type is in the United States National Museum in Washington. I have a small piece of this sponge, without gemmules, in my collection.

Distribution.—This species has been reported up to date from only one locality; namely, Taal Lake, Luzon, P. I.

Remarks.—"The most noteworthy characters of this sponge are the number and hairlike appearance of the free microscleres which are sometimes of unusual length in spite of their tenuity. Otherwise there is very little, except perhaps color, to distinguish it from some forms of *Spongilla lacustris.* The specimens I have examined are dry and appear to be somewhat worn on the external surface, but there is no trace of their having borne branches; the oscula seem to have been fairly large. The skeleton, in spite of the closeness of its reticulation, contains much less spongin than is usually the case in *Spongilla lacustris,* but this is a character liable to a certain amount of variation, although perhaps less inconstant than is usually thought."

EPHYDATIA FORTIS Weltner, 1895. Text fig. 4.

Historical statement.—This sponge was described by Weltner [10] from a specimen collected by Jagor from Libmanan River, Luzon. Unfortunately there were no drawings to accompany the original description. Through the kindness of Dr. W. Arndt, of the University Zoölogical Museum in Berlin where the type is preserved, I have been able to secure a very minute cotype of this sponge. The following description and the illustrations are based upon that material and are supplemented by a translation from the original description by the author of the species.

Habitat.—The specimen described by Weltner was found growing on the leaves of a small water plant, *Vallisneria,* in Libmanan River, Luzon.

General characteristics.—My small specimen seems to be a portion of a very thin crust or film, which was apparently taken from a plant leaf.

[10] Archiv. fur Naturg. (1895) 141.

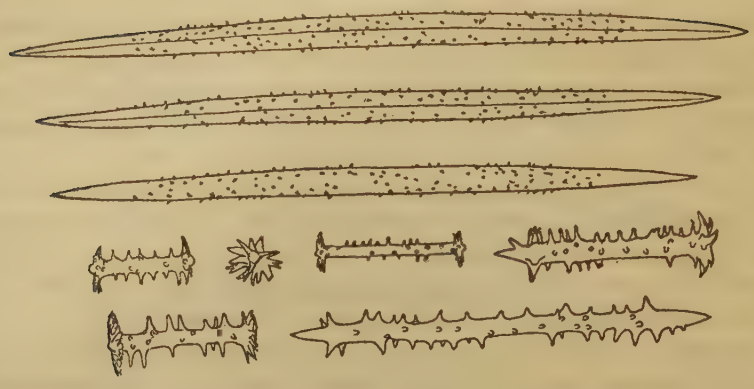

FIG. 4. *Ephydatia fortis* Weltner. Spiny skeleton spicules and five of the numerous variations in the gemmule spicules. (Drawings by C. F. Wu.)

Color.—When dry the sponge is white; the gemmules are also almost white, but are tinged with a very light brown. In alcohol the specimen is nearly transparent.

Structure.—The amount of spongin present is very small and the sponge appears to be very fragile. The long spicules, singly or in groups of two or three bound together near their ends, are woven into large open meshes. A thin basal membrane still shows the venation of the leaf to which the sponge was originally attached.

Skeleton spicules.—The large skeleton spicules are spindle-shaped, thickest in the center, gradually and sharply pointed; generally slightly curved, a few are straight; nearly always thickly covered, except near the ends, with minute spines perpendicular to the spicule; even the ends are sometimes finely granular in appearance; only occasionally are smooth or nearly smooth spicules found and most of these appear to be immature ones. My measurements show a slightly greater average length than Weltner's, but this might easily be caused by a chance selection of the spicules measured, and I consider it a matter of no special significance.

	Weltner.	Gee.
Length of spicules, μ	270–360	297–391
Average, around, μ	300	325
Diameter of spicules, μ	14–16	13–16

Flesh spicules.—There are no flesh spicules in this species.

Gemmules.—The gemmules occur singly in the meshes of the sponge. They are irregular in shape; some are nearly spherical,

while others are somewhat flattened out in one direction making them appear oblong. They are covered by a layer of birotulate spicules arranged perpendicularly to the surface of the gemmule, and in one gemmule the outer rotules were clearly visible as slight depressions in the thin cuticle that covered the gemmule. Weltner states that the pore tube is somewhat sunken in the air-cell layer. He also gives the average diameter of the gemmules as 480 μ. I measured two gemmules with the following results: 340 by 382 μ and 467 by 510 μ. The first gemmule measured had its covering spicules disarranged through handling, while in the second the cuticle was not disturbed. The measurements in both cases included the gemmule spicule layer.

Gemmule spicules.—The gemmule spicules vary a great deal in length and in general structure. While most of them are provided with the usual indented terminal rotules characteristic of the genus *Ephydatia,* yet quite a number of abnormal or irregular spicules occur. One of the commonest of these is a long (up to 135 μ or longer), heavily spined spicule that terminates in a large, smooth, sharp spine at each end; at the base of this spine there is a circle of shaft spines, somewhat larger than the others, that forms a rudimentary rotule. In some of the other spicules, which have the normal rotules, the shaft projects at one or both ends into a sharp point or spine beyond the rotule. My observations of the normal spicules agree in detail with those given by Weltner. The spicules vary in length from about 35 to 65 μ and the rotules have a diameter of from 20 to 28 μ. Both rotules of a spicule are usually of about the same diameter. They are irregularly incised, the teeth varying much in size, and in number from ten to twenty. The shaft is thickly covered with heavy spines, most of which usually bear smaller spines. There is much variation in the number of spines on the shafts of different gemmule spicules, some bear only eighteen or twenty, while others have as many as forty or more.

Type.—The type of this species is in the University Zoölogical Museum in Berlin. I have a minute cotype in my collection.

Distribution.—This species has been found only in Luzon, Philippine Islands. The writer has recently described [11] a variety of this species from specimens collected by Dr. J. R. Baker from the New Hebrides Islands.

[11] *Ephydatia fortis* var. *hebridensis,* Ann. and Mag. Nat. Hist. X 3 (1929) 28–33, figs.

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. *Spongilla philippinensis* Annandale. *a*, Showing both the smooth and the spined skeleton spicules; also one gemmule spicule (after Annandale); *b*, smooth skeleton spicules with axial canals clearly showing. (Drawing by C. F. Wu.)

2. *Spongilla clementis* Annandale. *a*, Spined and smooth skeleton spicules from specimens from Lake Biwa, Japan; the smaller spicules show the variations in gemmule spicules (after Annandale); *b*, skeleton and gemmule spicules of specimen from Lake Lanao, Mindanao; only smooth skeleton spicules were found (after Annandale).

3. *Spongilla microsclerifera* Annandale. Skeleton and fresh spicules. No gemmule spicules were found in my specimens. (Drawing by C. F. Wu.)

4. *Ephydatia fortis* Weltner. Spiny skeleton spicules and five of the numerous variations in the gemmule spicules. (Drawings by C. F. Wu.)

PLANKTON DIATOMS FROM VLADIVOSTOK BAY

By B. W. Skvortzow

Of Harbin, China

TWO PLATES

The diatoms included in this paper were collected by Mr. N. E. Kabanov and me in Vladivostok Bay July 18, 1928. So far as I know, there is no published list of plankton diatoms from this part of the Sea of Japan and the enumeration will be of interest. The number of forms in the present collection is not great, but there are some interesting ones. I am describing a species of *Synedra* as new.

LEPTOCYLINDRUS DANICUS Cleve. Plate 2, fig. 3.

Cleve, Pelag. Diat. fr. Kattegat (1889) 54; Planktonundersokningar Cilioflag. och Diat. (1894) 15, pls. 1, 2, figs. 4, 5; Hustedt in A. Schmidt, Atlas Diatom. (1920) pl. 321, fig. 12; Kieselalgen (1929) 558–59, figs. 318, 319.

Cells cylindrical, with flat ends, forming filaments. Valves without structure. Chromatophores numerous. Diameter of filaments, 0.007 to 0.008 millimeter. Geographic distribution: Atlantic and Pacific Oceans.

SCELETONEMA COSTATUM (Grev.) Cleve. Plate 2, fig. 4.

Cleve, Bih. Kongl. Sv. Vet.-Akad. Handl. 5 (1878) 18; A. Schmidt, Atlas Diatom. (1892) pl. 180, figs. 41–45; (1920) pl. 321, figs. 5, 6; Hustedt, Kieselalgen (1928) 311–13, fig. 149.

Cells 0.007 to 0.009 millimeter broad, 0.018 to 0.022 in length. Geographic distribution: A typical pelagic diatom known from the Atlantic and Pacific Oceans.

DITYLIUM BRIGHTWELII (West) Grun.

V. Heurck, Synopsis (1885) pl. 114, figs. 3–9.

Cells 0.12 to 0.15 millimeter in length, 0.025 to 0.035 in breadth. Geographic distribution: Common in plankton of oceans, known from the Sea of Japan.

CHAETOCERAS SOCIALE Lauder. Plate 1, fig. 2.

LAUDER, Diatom. Hong Kong (1864) 77, pl. 8, fig. 1.

I am giving here the original diagnosis of this species, from Henry Scott Lauder:

Filaments slender, aggregated, embedded in gelatine, with wiry spirally dotted awns, some of which are more elongate and converge to a common centre. This is the smallest species I have seen. By the aggregation of the filaments in gelatine, it forms roundish, flattened fronds. Frustules quadrate with an awn from a little within each angle, one of them being more elongated, varying in the length, according to the distance of the frustules, to a common centre, to which the elongated awns converge: many frustules, however, occur in which the awns are not thus connected: side view oval.

Our specimens were 0.008 to 0.01 millimeter in diameter. Geographic distribution: Atlantic and Pacific Oceans; known from Japanese waters.

CHAETOCERAS CRIOPHILUM Castracane forma VOLANS (Schutt) Gran. Plate 1, figs. 5 and 6.

CASTRACANE, Diatom. Challenger (1886) 78; GRAN, Diatom. Arct. Meere (1904) 532–33, fig. 4; Nord. Plankton (1906) 71, fig. 85; GRAN and YENDO, Japan Diatom. (1914) 7; OKAMURA, Littor. Diatom. Japan (1911) 90, pl. 3, figs. 33–37; KARSTEN, Phytopl. Antarkt. Meeres (1905) 118, pl. 15, fig. 8; PERAGALLO, Diatom. Mar. France (1908) 475; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 342, figs. 2, 3.

Cells solitary, 0.02 to 0.023 millimeter broad, from front view quadrangular with angles. Setæ very robust, curved, covered with solid spines. Geographic distribution: Atlantic and Pacific Oceans; the Sea of Japan.

CHAETOCERAS COMPRESSUM Lauder. Plate 1, fig. 1.

LAUDER, Diatom. Hong Kong (1864) 78, pl. 8, fig. 6.

Chain straight, 0.01 to 0.018 millimeter broad. Spores with verrucose dots on the margin. Geographic distribution: Common in Atlantic and Pacific Oceans. Reported from the Sea of Japan.

CHAETOCERAS COMPRESSUM var. GRACILIS Hustedt. Plate 1, fig. 7.

HUSTEDT, in A. Schmidt, Atlas Diatom. (1921) pl. 338, fig. 7.

Chain thinner, 0.006 to 0.008 millimeter broad. Geographic distribution: Known only from the Sea of Japan.

CHAETOCERAS DIDYMUM Ehrenb. var. ANGLICA Gran. Plate 1, fig. 3.

GRAN, Nord. Plankton (1906) 80, fig. 95.

Cells forming a straight chain, 0.02 to 0.03 millimeter broad. Cells in the front view rectangular with a large dot in the middle

part. Setæ start at a little inside of the margin. Geographic distribution: Atlantic and Pacific Oceans; Sea of Japan.

CHAETOCERAS GRACILE Schütt. Plate 1, fig. 10.

SCHÜTT, Chaetocera and Peragallo. (1895) 42, figs. 13*a–d.*

Chaetoceras septentrionale OESTRUP, Mar. Diatom. Gronland. (1895) 457, pl. 7, fig. 88; GRAN, Diatom. Arkt. Meere (1904) 542; PAULSEN, On some Perid. a. Plankt. Diatom. (1905) 5–6, fig. 6.

Cells solitary, 0.015 to 0.025 millimeter broad; in the front quadrangular and in valve view elliptical. Setæ thin, very long. Geographic distribution: Atlantic Ocean.

CHAETOCERAS DECIPIENS Cleve. Plate 1, fig. 8.

CLEVE, Diatom. Arct. Sea (1873) 11, fig. 5.

Chain straight, with rectangular cells, 0.035 to 0.55 millimeter broad. Geographic distribution: Atlantic and Pacific Oceans; Sea of Japan.

CHAETOCERAS CONSTRICTUM Gran. Plate 2, fig. 2.

GRAN, Tret. Phytopl. N. Atlant. (1897) 17, pls. 11–13, pl. 3, fig. 42; Nord. Plankton (1906) 80, fig. 96; OKAMURA, Chaetoceras and Perag. Japan (1907) 96, pl. 4, figs. 64a, b; PERAGALLO, Diatom. Mar. France (1908) 491, pl. 134, fig. 5; HUSTEDT in A. Schmidt, Atlas Diatom. (1921) pl. 338, fig. 1.

Chain straight, 0.01 to 0.012 millimeter broad. Cells in a front view rectangular with slightly projecting angles, valves concave, foramina lanceolate, constricted. Girdle band one-third of the cell height. Setæ thin, starting from the angles of the valve, crossing one another close to their insertions, diverging at an obtuse angle. Terminal setæ are not differentiated. Geographic distribution: Atlantic and Pacific Oceans.

Okamura reports this species from the Kuriles.

CHAETOCERAS LACINIOSUM Schütt. Plate 2, fig. 1.

SCHÜTT, Arten Chaetoceras u. Peragallo. (1895) 38, figs. 5a–c; GRAN, Phytopl. N. Atlant. (1897) 17, figs. 4–7; Nord. Plankton. (1906) 82, fig. 99; GRAN and YENDO, Japan Diatom. (1914) 18–19, fig. 11.

Chaetoceras distans CLEVE, Plankton. Cilioll. och. Diatom. (1894) 14, pl. 2, fig. 3.

Chaetoceras distans OSTENFELD, Flora Koh-Chang (1902) 255, fig. 13.

Chaetoceras commutatum CLEVE, Plankton. Vegetabil. (1896) 28, figs. 9, 10.

Chaetoceras ostenfeldii CLEVE, Plankt. N. Sea (1900) 21, pl. 8, fig. 19.

Chaetoceras pelagicum CLEVE, Diatom Arct. Sea (1873) 11, pl. 1, fig. 4.

Chaetoceras distans var. *laciniosa* SCHÜTT in Peragallo, Diatom. Mar. France (1908) 483, pl. 132, fig. 6; IKARI, Chaetoceras Japan (1928) 253–54, fig. 8a.

Chain straight, 0.01 to 0.015 millimeter broad, composed of many cells. Foramina large, as long as the cell height and elliptical, slightly constricted in the middle. Valves in a front view rectangular with projecting angles. Girdle band rather longer, about two-thirds of the cell height. Setæ thin, starting from the angles of the valve, crossing one another close to their insertions, diverging at an obtuse angle. Terminal setæ are disposed parallel. Geographic distribution: Common in Atlantic and Pacific Oceans. Known in Japanese waters from Oshoro, Takashima, Ajiro, Naha, Volcano Bay, Misume, and Seto.

CHAETOCERAS sp. Plate 1, fig. 4.

Chain straight, 0.012 to 0.015 millimeter wide. Cells in a front view rectangular, valves concave, foramina lanceolate. Girdle band rather longer, about one-third of the cell height. Setæ thin, irregularly disposed, terminal setæ long, more or less divergent.

THALASSIOTHRIX NITZSCHIOIDES Grun. Plate 2, figs. 7 and 8.

V. HEURCK, Synopsis (1883) 43, fig. 7.

A common pelagic diatom forming zigzag clusters. Cells lanceolate, 0.012 to 0.074 millimeter in length, 0.0025 to 0.003 in breadth with marginal striæ 12 to 15 in 0.01 millimeter. Geographic distribution: North Atlantic and Pacific Oceans.

THALASSIOTHRIX FRAUENFELDII Grun. Plate 2, fig. 9.

V. HEURCK, Synopsis (1883) pl. 37, figs. 11–13.

Cells forming star-shaped or zigzag clusters. Cells 0.002 to 0.15 millimeter in length. Geographic distribution: Atlantic and Pacific Oceans. Sea of Japan.

THALASSIOTHRIX ANTARCTICA Schimper. Plate 2, figs. 5 and 6.

KARSTEN, Phytopl. Atlant. Meeres (1905) 124, pl. 17, fig. 12.

Cell filiform, curved, 1.32 to 1.65 millimeters in length, 0.0037 to 0.005 in breadth. Striæ 14 to 16 in 0.01 millimeter. Geographic distribution: Atlantic and Pacific Oceans.

ASTERIONELLA JAPONICA Cleve. Plate 2, figs. 10 and 11.

OKAMURA, Littor. Diatom. Japan (1911) 11, pl. 13, fig. 56.

A typical pelagic diatom forming star-shaped and zigzag clusters. Cells length 0.045 to 0.144 millimeter. Geographic distribution: Atlantic and Pacific Oceans; Sea of Japan.

SYNEDRA AFFINIS Kutz. var. GRACILIS Grun.

V. HEURCK, Synopsis (1883) pl. 41, fig. 15B; PERAGALLO, Diatom. Mar. France (1908) 320, pl. 130, figs. 23, 24.

Valve lanceolate, in the middle part inflated. Length, 0.35 to 0.44 millimeter; breadth, 0.012; striæ 12 in 0.01 millimeter. Geographic distribution: A littoral diatom known from the Atlantic and Pacific Oceans and Mediterranean Sea.

SYNEDRA JAPONICA sp. nov. Plate 2, fig. 13.

Cell free, linear or linear-lanceolate, pseudoraphe distinct. Valve 0.48 to 0.59 millimeter in length, in the middle part, 0.0034 to 0.0045 in breadth; striæ 15 in 0.01 millimeter.

RHIZOSOLENIA ALATA Bright. forma GRACILLIMA (Cleve) Grun.

PERAGALLO, Monogr. Rhizosolenia (1892) 20, pl. 5, fig. 12; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 317, figs. 8–10.

Cells 0.85 to 0.88 millimeter in length and 0.0074 in breadth. Geographic distribution: Common in plankton in Atlantic and Pacific Oceans.

RHIZOSOLENIA SETIGERA Bright.

PERAGALLO, Monogr. Rhizosolenia (1892) 17, pl. 4, fig. 12–16.

Cell linear, hyaline, 0.65 to 0.75 millimeter in length and 0.011 in breadth. Spine thin, 0.04 to 0.07 millimeter in length. Geographic distribution: Atlantic, Pacific and Indian Oceans, Sea of Japan.

NITZCHIELLA LONGISSIMA (Bréb.) Ralfs forma PARVA V. Heurck. Plate 2, fig. 12.

V. HEURCK, Synopsis (1883) pl. 70, fig. 3.

Length, 0.118 to 0.2 millimeter; breadth in the middle part, 0.0035 to 0.004. Geographic distribution: Littoral diatom, cosmopolitan.

PLEUROSIGMA FASCIOLA Ehrenb. var. ARCUATUM Donk. Plate 1, fig. 9.

Pleurosigma arcuatum DONKIN, T. M. S. (1858) 25 fig. 10; CLEVE, Synopsis Navic. Diatoms (1894) Part I, II; PERAGALLO, Monogr. Pleurosigma (1890 to 1891) 26, pl. 8, figs. 34, 35.

Valve lanceolate, with produced beak-shaped ends. Length, 0.1 to 0.15 millimeter; breadth, 0.015 to 0.018. Geographic distribution: A littoral diatom known from the Atlantic and Pacific Oceans.

ILLUSTRATIONS

Plate 1

Fig. 1. *Chaetoceras compressum* Lauder.
2. *Chaetoceras sociale* Lauder.
3. *Chaetoceras didymum* Ehrenb. var. *anglica* Gran.
4. *Chaetoceras* sp.
5. *Chaetoceras criophilum* Castr. f. *volans* (Schütt) Gran.
6. *Chaetoceras criophilum* Castr. f. *volans* (Schütt) Gran.
7. *Chaetoceras compressum* Lauder var. *gracilis* Hustedt.
8. *Chaetoceras decipiens* Cleve.
9. *Pleurosigma fasciola* Ehrenb. var. *arcuatum* Donk.
10. *Chaetoceras gracile* Schütt.

Plate 2

Fig. 1. *Chaetoceras laciniosum* Schütt.
2. *Chaetoceras constrictum* Gran.
3. *Leptocylindrus danicus* Cleve.
4. *Sceletonema costatum* (Grev.) Cleve.
5. *Thalassiothrix antarctica* Schimper.
6. *Thalassiothrix antarctica* Schimper.
7. *Thalassiothrix nitzschioides* Grun.
8. *Thalassiothrix nitzschioides* Grun.
9. *Thalassiothrix frauenfeldii* Grun.
10. *Asterionella japonica* Cleve.
11. *Asterionella japonica* Cleve.
12. *Nitzchiella longissima* (Bréb.) Ralfs f. *parva* V. Heurck.
13. *Synedra japonica* sp. nov.

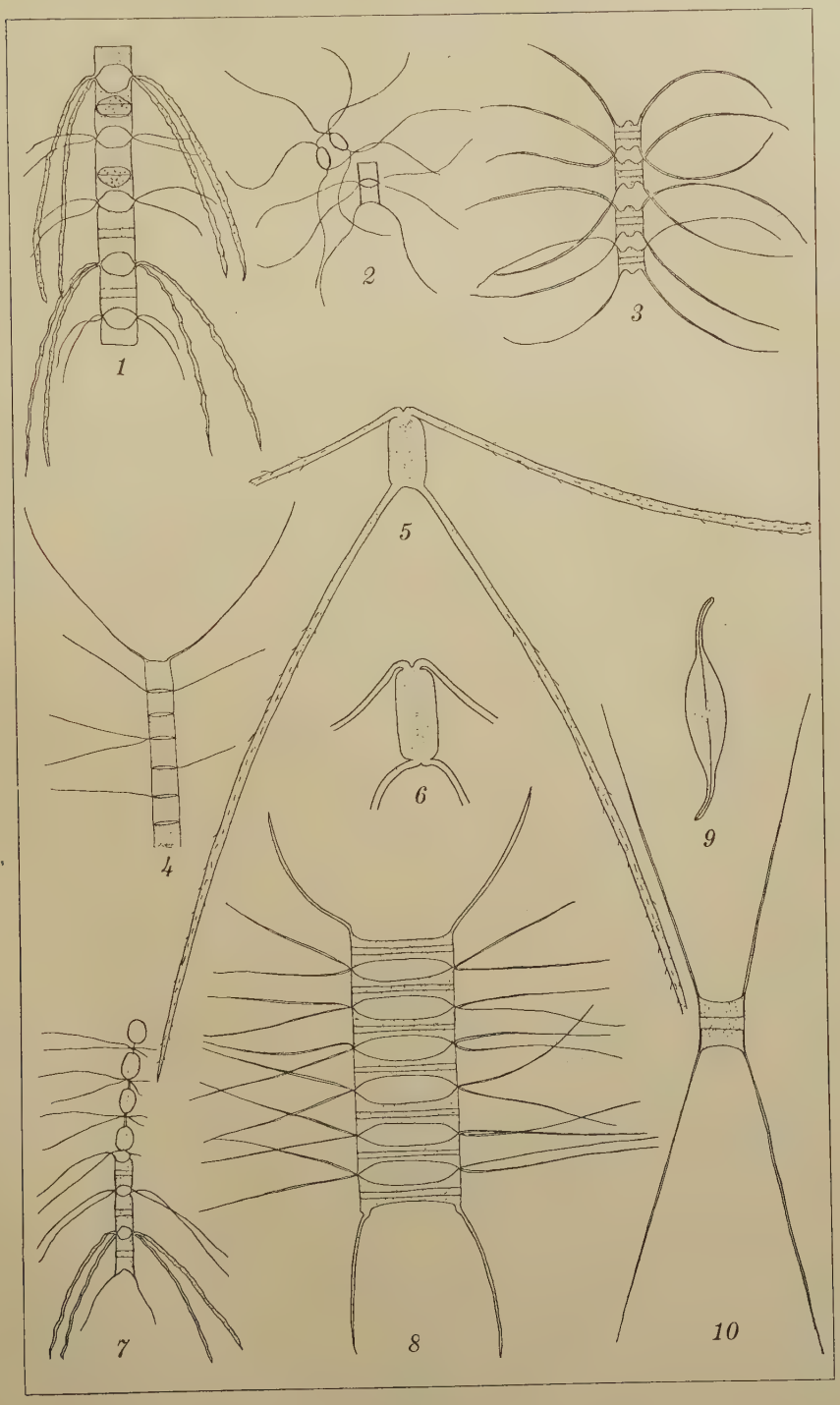


PLATE 1.

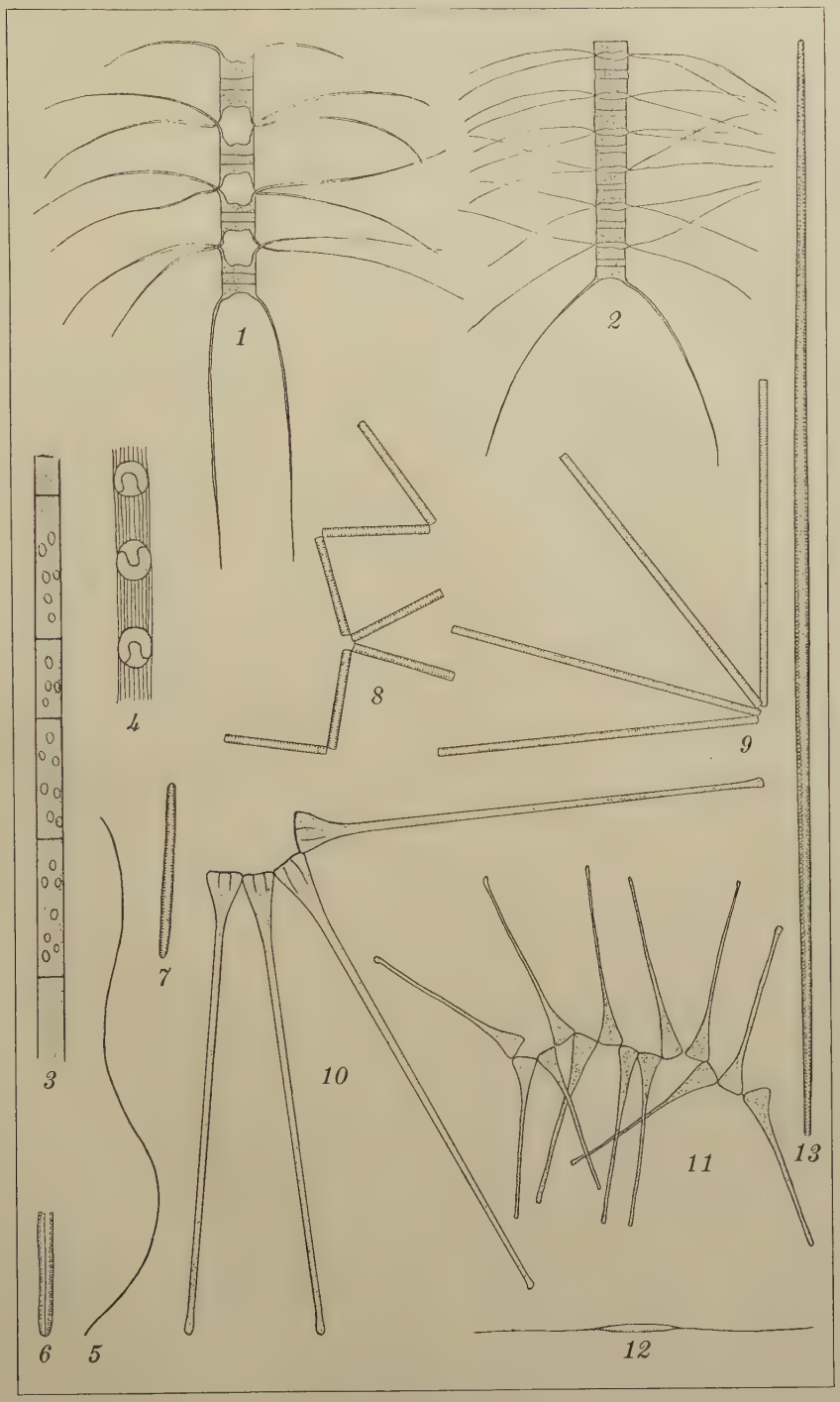


PLATE 2.

MYCETOZOA FROM NORTH MANCHURIA, CHINA [1]

By B. W. Skvortzow

Of Harbin, China

FIVE PLATES

A certain amount of work has been done on the Mycetozoa of some parts of Europe and the western parts of Asia, but the slime fungi of eastern Asia, especially of Manchuria, have been completely overlooked. Contributions to the Mycetozoa of Siberia have been published by Dr. N. N. Lavrov, of the Tomsk University of Siberia, USSR, and the Japanese Mycetozoa were studied by A. and G. Lister, in Mycetozoa from Japan;[2] and by K. Ninakata, in the list of Japanese Myxomycetes.[3]

The Mycetozoa that form the subject of this paper were collected by the author in North Manchuria in 1920 to 1929, especially in Harbin and in the mountainous part of the country near Erth'enkiangtzu and Maoershan station on the Chinese Eastern Railway. The number of forms found in the present collection is not great, but there are some interesting ones. In this note thirty-two slime fungi are enumerated and ten are described as new; namely, *Badhamia mandshurica, Physarum compressum, Ph. griseum, Ph. mandshuricum, Ph. asiaticum, Diderma rugosum* Macb. var. *asiatica, Lepidoderma mandshurica, Licea brassica, L. mandshurica,* and *Trichia asiatica.*

The Mycetozoa are cosmopolitan in their distribution and the finding of new species in the eastern part of Asia is of scientific interest. Most Manchurian forms of Mycetozoa are characteristic of temperate regions; such are, *Fuligo septica, F. muscorum, Diderma spumarioides, Stemonitis splendens, S. herbatica, Lycogala epidendrum, Trichia persimilis, T. contorta, Hemitrichia clavata, Arcyria denudata, A. cinerea,* and *Perichaena depressa.* Some species of slime fungi, *Ceratiomyxa fruti-*

[1] From the laboratory of natural history of the Third High School of the Chinese Eastern Railway Co., Harbin, China. (Formerly the Commercial School.)

[2] Journ. of Bot. 42 (1904) 97–99, t. 458; 42 (1906) 227–230.

[3] Bot. Mag. Tokyo 42 (1908) 317.

culosa, Didymium dubium, Licea biforis, Arcyria carnea, and others, are here recorded from Asia for the first time. All *Physarum* species found in Manchuria are identified as new to science.

This note is illustrated by diagrams by the author and by photographs made by Ica mikro-camera with Planar 1:4.5 F = 2 cm of Carl Zeiss.

CERATIOMYXA FRUTICULOSA Macbr. var. FLEXUOSA Lister. Plate 4, fig. 3.

Sporophores long, branching, white, 1 to 3 millimeters high. Branches of sporophores 30 to 60 microns, thickly covered with spines. Spores white, smooth, ovoid, 8 to 13 microns long. Habit: On rotten wood; near Maoershan station, Chinese Eastern Railway, August, 1928. Geographic distribution: Abundant in the Tropics; recorded in Europe, Japan, and South Africa.

BADHAMIA MANDSHURICA sp. nov. Plate 2, figs. 6, 7, and 8.

Plasmodium unknown. Sporangia subglobose, sessile, minute, 0.2 to 0.5 millimeter in diameter, scattered or in small clusters, black, somewhat rugose and gray; sporangium wall membranous, with scanty deposits of lime granules. Capillitium a network of slender threads with white lime deposits. Spores free, blackish brown, round, somewhat minutely spinulose, 13 to 15.5 microns in length. Habit: On the bark of trees; Harbin, August, 1920.

PHYSARUM COMPRESSUM sp. nov. Plate 1, figs. 7, 8, and 9.

Sporangia stalked, gregarious, discoid or compressed, sometimes umbilicate above, 0.4 to 1 millimeter in diameter, grayish white, rugulose; sporangium wall membranous, with abundant deposits of white lime granules. Stalk furrowed, yellow-brown. Capillitium a persistent network of stout, rigid, hyaline threads and numerous rounded dark yellow-brown lime knots. Spores 11 to 12 microns in diameter, brown, spinulose. Habit: On dead wood; Harbin, August, 1920.

PHYSARUM GRISEUM sp. nov. Plate 1, figs. 4, 5, and 6.

Sporangia sessile, subglobose or elongate, clustered, grayish white, 0.4 to 0.7 millimeter in diameter, rugulose; sporangium wall membranous, with lime granules. Capillitium consisting of short hyaline threads connected by angular branching brown-yellow lime knots. Spores purplish brown, spinulose, 9.2 to 12 microns in diameter. Habit: On dead wood; Harbin, November, 1920.

PHYSARUM MANDSHURICUM sp. nov. Plate 1, figs. 1, 2, and 3.

Sporangia subglobose, reniform, stalked, erect or somewhat inclined, scattered or clustered, two or more often borne on a single stalk, 0.3 to 0.7 millimeter in diameter, white, rugose; sporangium wall membranous, with white granules. Stalk subulate or cylindrical, furrowed, 1 millimeter long, yellow-brown, usually free from refuse matter. Capillitium a network of colorless branching threads, lime knots large, not numerous. Spores dark reddish brown, spinulose, 11 to 12 microns in diameter. Habit: On dead bark of trees; Maoershan station, Chinese Eastern Railway, August, 1928.

PHYSARUM ASIATICUM sp. nov. Plate 2, figs. 9, 10, and 11.

Sporangia subglobose or irregularly ovoid, 0.2 to 0.5 millimeter in diameter, sessile, heaped or gregarious, rugose, whitish black; sporangium wall membranous, with dense included clusters of minute white lime granules. Capillitium a network of dark brown threads, with irregular dark brown lime knots. Spores dark violet-brown, 10 to 12 microns in diameter, spinulose. Habit: On bark of trees; Harbin, September, 1920.

FULIGO SEPTICA Gmelin. Plate 3, fig. 3; Plate 4, fig. 4.

Æthalia pulvinate, 0.5 to 7 centimeters broad, light yellow. Capillitium consisting of a loose network with yellow lime knots. Spores violet, smooth, 6.8 to 9.5 microns in diameter. Habit: On dead wood and earth; Harbin, July, August, and September, 1929. Geographic distribution: Abundant in temperate and tropical regions.

FULIGO SEPTICA Gmelin var. RUFA R. E. Fries. Plate 3, fig. 2.

Æthalia pulvinate, 2 to 4 centimeters in diameter, brick red or yellow-red. Capillitium scanty, consisting of a loose network of slender hyaline threads. Spores violet-brown, 6.8 to 9.6 microns in diameter. Habit: On earth and on leaves; near Maoershan station, Chinese Eastern Railway, August, 1928. Geographic distribution: Abundant in temperate and tropical regions.

FULIGO MUSCORUM Alb. and Schwein.

Æthalia pulvinate, 0.4 to 0.8 millimeter in diameter, scattered, yellow. Capillitium of numerous irregular large orange lime knots. Spores violet-brown, spinulose, 10.2 to 12 microns in diameter. Habit: On bark of *Cladrastis amurensis;* Maoershan station, Chinese Eastern Railway, August, 1928. Geographic distribution: Europe and Ceylon.

DIDERMA GLOBOSUM Pers. Plate 4, fig. 2.

Sporangia subglobose, sessile, forming large colonies, 0.2 to 0.5 millimeter in diameter, white-gray; sporangium wall of two layers, the outer eggshell-like, composed of globular lime granules. Columella indistinct. Capillitium dark brown branched threads. Spores dark black-brown, fine spinulose, 11 to 11.5 microns in diameter. Habit: On leaves and twigs of *Carex* sp. and *Artemisia* sp.; near Maoershan station, Chinese Eastern Railway, August, 1928. Geographic distribution: Recorded from Europe, United States, and British Columbia.

DIDERMA SPUMARIOIDES Fries.

Sporangia crowded, forming colonies, globose, sessile, 0.5 to 1.5 millimeters in diameter, smooth, white. Sporangium wall of two layers. Capillitium slender threads. Spores dark reddish brown, spinulose, 7.4 to 11.1 microns in diameter. Habit: On dead wood; Harbin, August, 1920. Geographic distribution: Europe, United States, Canada, Ceylon, Japan, West Indies, Bermuda, and southern Chile.

DIDERMA RUGOSUM Macbride var. ASIATICA var. nov.

Plasmodium gray. Sporangia stalked, subglobose, 0.4 to 0.5 millimeter in diameter, grayish white, reticulated, wrinkled. Sporangium wall single, with deposits of lime in minute granules. Stalk 0.5 to 0.7 millimeter high, furrowed, yellow-brown. Columella clavate, about half the height of the sporangium. Capillitium consisting of slender colorless threads, anastomosing and branching towards the tips. Spores purplish brown, minutely warted, 7.5 to 9 microns in diameter. Habit: On leaves of *Brassica chinensis;* Harbin, August, 1928. Geographic distribution: The typical *Diderma rugosum* was recorded from Europe, Ceylon, Japan, America, and United States.

LEPIDODERMA MANDSHURICA sp. nov. Plate 2, figs. 1, 2, and 3; Plate 5, fig. 2.

Sporangia forming short, subglobose or elongate pulvinate plasmodiocarps, 0.5 millimeter to 5 centimeters long, 0.5 to 5 millimeters broad, silvery gray, clothed with brilliant crystalline scales of lime; capillitium of slender brownish threads, branched and anastomosing. Spores brown-violet, smooth, 6.8 to 7.2 microns in diameter. Habit: On leaves and dead twigs, Maoershan station, Chinese Eastern Railway, August, 1928.

STEMONITIS SPLENDENS Rost. var. FLACCIDA Lister.

Sporangia cylindrical, obtuse, stalked, dark brown, adhering to each other, forming large colonies. Stalk black. Total height

1 to 1.8 centimeters. Capillitium of purplish brown branching threads. Spores dark brown, 7.4 to 7.8 microns in diameter. Habit: On dead wood; Erth'enkiangtzu station, Chinese Eastern Railway, July, 1927. Geographic distribution: Europe and America.

STEMONITIS HERBATICA Peck.

Sporangia cylindrical, closely clustered, 8 to 10 millimeters high, brown. Stalks 2 to 3.5 millimeters high. Capillitium brown threads, forming a loose network. Spores smooth, 5.1 to 5.4 microns in diameter. Habit: On dead wood; Maoershan station, Chinese Eastern Railway, August, 1928. Geographic distribution: Europe, United States, Ceylon, and Japan.

DICTYDIUM CANCELLATUM Macbr.

Sporangia subglobose, dark red-brown, stalked, formed of numerous ribs, connected by slender transverse threads, 1.5 to 2 millimeters high and 0.3 to 0.5 millimeter broad. Spores red, 5.2 to 5.7 microns in diameter, minutely warted. Habit: On dead wood; Harbin, August, 1920. Geographic distribution: Europe, Africa, America, and Japan.

LICEA BIFORIS Morgan.

Sporangia scattered, ellipsoid, elongate, sessile, 0.1 to 0.3 millimeter long, 0.06 to 0.1 millimeter broad, yellow-brown. Spores round, smooth, light yellow, 9.2 to 11.1 microns in diameter, with oil drops. Habit: On dead bark; Harbin, November, 1929. Geographic distribution: Japan, Pennsylvania, Ohio, and Canada.

LICEA BRASSICA sp. nov. Plate 3, fig. 4.

Sporangia scattered, depressed, forming straight, curved, or branching plasmodiocarps 0.5 to 5 millimeters long, grayish white, reticulated and little wrinkled. Sporangium wall single, with deposits of lime in minute granules. Spores purplish brown, smooth, 9.2 to 9.5 microns in diameter. Habit: On leaves of *Brassica chinensis*. This species somewhat resembles *Licea flexuosa* Pers., but differs from it in the color of the sporangium wall and by the spores.

LICEA MANDSHURICA sp. nov. Plate 2, figs. 4 and 5.

Sporangia sessile, depressed, forming straight, curved, and wrinkled plasmodiocarps, 1.5 millimeters long, olive or dark gray, more or less closely covered with flat, rounded, angular crystalline scales of lime. Capillitium and columella wanting.

Spores dark violet-brown, 6 to 7.2 microns in diameter, nearly smooth. Habit: On earth; Harbin, August, 1929.

LYCOGALA EPIDENDRUM Fries.

Æthalia subglobose, 5 to 6 millimeters in diameter, dark gray, warted. Pseudocapillitium in the form of tubes, marked with close transverse wrinkles. Spores gray, spinulose, 6.8 to 8.5 microns in diameter. Habit: On dead wood; Harbin, August, 1920. Geographic distribution: British Isles and frequent in all temperate and tropical regions.

TRICHIA PERSIMILIS Karst.

Sporangia globose, sessile, forming large colonies, 0.3 to 0.6 millimeter in diameter, yellow-brown. Capillitium 3.8 to 4 microns in diameter, with spiral bands and short spines. Spores yellow, 11.1 to 11.4 microns in diameter, with pitted warts. Habit: On rotten wood; Maoershan station, Chinese Eastern Railway, August, 1928. Geographic distribution: British Isles, Europe, Ceylon, Java, and Peru.

TRICHIA VARIA Pers.

Sporangia globose, ovoid, only sessile, 0.5 to 1 millimeter in diameter, forming large colonies. Sporangium wall membranous, pale yellow. Capillitium yellow, elater 3.5 to 4.5 microns in diameter, tapering at the ends, with two spiral bands. Spores yellow, minutely warted, 11 to 13 microns in diameter. Habit: On dead wood; Harbin, November, 1920. Geographic distribution: Europe, United States, Ceylon, and northern India.

TRICHIA CONTORTA Rost. var. INCONSPICUA Lister.

Sporangia clustered, forming large colonies; 0.2 to 0.7 millimeter in diameter, sessile, brown; sporangium wall membranous, reddish brown. Capillitium simple, elaters with four distinct spiral bands, 3.7 to 4 microns in diameter. Spores yellow, minutely spinulose, 11 to 13 microns in diameter. Habit: On bark of trees; Harbin, 1920. Geographic distribution: Widely distributed throughout north temperate regions.

TRICHIA ASIATICA sp. nov. Plate 1, figs. 10, 11, and 12.

Sporangia globose, usually crowded and seated on a common membranous hypothallus, 0.5 to 0.8 millimeter in diameter, brown or yellow-brown, shining. Capillitium and spores in mass yellow; sporangium wall membranous, yellow. Capillitium of bright yellow or orange elaters, 3.5 to 4 microns in diameter, with four bands, forming a close spiral studded with

many spines. Spores dark yellow-brown, minutely warted, 10 to 12.5 microns in diameter. Habit: On bark of trees; Harbin, November, 1929.

HEMITRICHIA SERPULA Rosr. Plate 5, fig. 1.

Sporangia forming winding branched plasmodiocarps, 0.2 to 0.5 millimeter wide, uniting into a close net, golden yellow; sporangium wall membranous, yellow. Capillitium elastic yellow threads, 4 to 4.5 microns in diameter, marked with spiral bands, spinose. Spores yellow, reticulated with bands, forming a regular net, 11 to 11.5 microns in diameter. Habit: On bark of trees; Maoershan station, Chinese Eastern Railway, August, 1928. Geographic distribution: Europe, abundant in Japan, United States, the Tropics, Australia, New Zealand, and the Cape Province.

HEMITRICHIA VESPARIUM Macbr.

Sporangia clavate, stalked, crowded, 1 to 1.4 millimeters high, dark red. Stalks combined in clusters of from five to ten, red. Capillitium red, twisting threads, 5.7 to 6 microns in diameter, with spiral bands and numerous scattered spines. Spores red, warted, 11 microns in diameter. Habit: On dead wood; Harbin, October, 1920. Geographic distribution: Recorded from most temperate and tropical regions; United States.

HEMITRICHIA CLAVATA Rost.

Sporangia stalked, gregarious or crowded, 0.9 to 2 millimeters high, olivaceous-yellow; sporangium wall yellow. Stalk red-brown. Capillitium a network of branched yellowish threads, 5.3 to 5.7 microns in diameter, marked with five spiral bands, without spines. Capillitium ends subclavate. Spores dark brown, warted, 7.2 to 7.6 microns in diameter. Habit: On dead wood; Maoershan station, Chinese Eastern Railway, August, 1928. Geographic distribution: Widely distributed and common in all temperate and tropical regions.

ARCYRIA DENUDATA Wettstein.

Sporangia stalked, ovoid or cylindrical, 0.6 to 2 millimeters high, 0.4 to 1.2 millimeters broad, reddish or reddish brown. Capillitium a close elastic network of red threads with thickenings of cogs or spines and half-rings. Spores red, smooth, 6 to 7 microns in diameter. Habit: On dead wood and bark of trees; Maoershan station, Chinese Eastern Railway, August, 1928. Geographic distribution: Abundant in temperate and tropical regions.

ARCYRIA CINEREA Pers. Plate 4, fig. 1.

Sporangia stalked, almost gregarious, cylindrical, 0.7 to 1.2 millimeters long, 0.4 to 0.7 millimeter in diameter; pale gray. Stalk 0.4 to 0.6 millimeter long, dark gray. Capillitium a close network of gray threads, warted and spinulose. Spores gray, smooth, 6 to 6.5 microns in diameter. Habit: On dead wood; Harbin, November, 1929. Geographic distribution: Common and widely distributed in temperate regions.

ARCYRIA CARNEA G. Lister.

Sporangia stalked, clustered, ovoid or shortly cylindrical, flesh-colored, 1.5 to 2 microns high; cup plaited at the base, red. Stalks black. Capillitium a close and only slightly elastic network of dark red threads, 3.7 to 4.5 microns in diameter, marked with a loose spiral of flat-tipped cogs or spines. Spores reddish, 6.8 to 7.4 microns in diameter, smooth. Habit: On dead wood; Maoershan station, Chinese Eastern Railway, August, 1928. Geographic distribution: Europe and Japan.

PERICHAENA DEPRESSA Libert.

Sporangia sessile, crowded, flattened, 0.1 to 0.5 millimeter in diameter, sometimes forming short branching plasmodiocarps of 1 to 3 millimeters diameter, purple-brown. Sporangium wall of two layers. Capillitium branched yellow threads, minutely warted. Spores yellow, warted, 9 to 11 microns in diameter. Habit: On dead bark of *Populus simonii;* Harbin, November, 1929. Geographic distribution: Widely distributed in temperate and tropical regions.

ILLUSTRATIONS

Plate 1

Figs. 1 to 3. *Physarum mandshuricum* sp. nov.; *1*, sporangia, × 20; *2* and *3*, capillitium and spore, × 500.
4 to 6. *Physarum griseum* sp. nov.; *4*, sporangia, × 20; *5* and *6*, capillitium and spore, × 500.
7 to 9. *Physarum compressum* sp. nov.; *7*, sporangia, × 20; *8* and *9*, capillitium and spore, × 500.
10 to 12. *Trichia asiatica* sp. nov.; *10*, sporangia, × 20; *11* and *12*, capillitium and spore, × 500.

Plate 2

Figs. 1 to 3. *Lepidoderma mandshurica* sp. nov.; *1*, sporangia, × 20; *2* and *3*, capillitium and spore, × 500.
4 and 5. *Licea mandshurica* sp. nov.; *4*, sporangia, × 20; *5*, spores, × 500.
6 to 8. *Badhamia mandshurica* sp. nov.; *6*, sporangia, × 20; *7* and *8*, capillitium and spore, × 500.
9 to 11. *Physarum asiaticum* sp. nov.; *9*, sporangia, × 20; *10* and *11*, capillitium and spore, × 500.

Plate 3

Fig. 1. *Trichia persimilis* Karst., sporangia, × 15.
2. *Fuligo septica* Gmelin var. *rufa* R. E. Fries, æthalia, × 1. 5.
3. *Fuligo septica* Gmelin, æthalia, × 1. 5.
4. *Licea brassica* sp. nov., sporangia, × 10.

Plate 4

Fig. 1. *Arcyria cinerea* Pers., sporangia, × 15.
2. *Diderma globosum* Pers., sporangia, × 15.
3. *Ceratiomyxa fruticulosa* Macbr. var. *flexuosa* Lister, sporophores, × 15.
4. *Fuligo septica* Gmelin, æthalia, × 1. 5.

Plate 5

Fig. 1. *Hemitrichia serpula* Rost., sporangia, × 8.
2. *Lepidoderma mandshurica* sp. nov., sporangia, × 5.

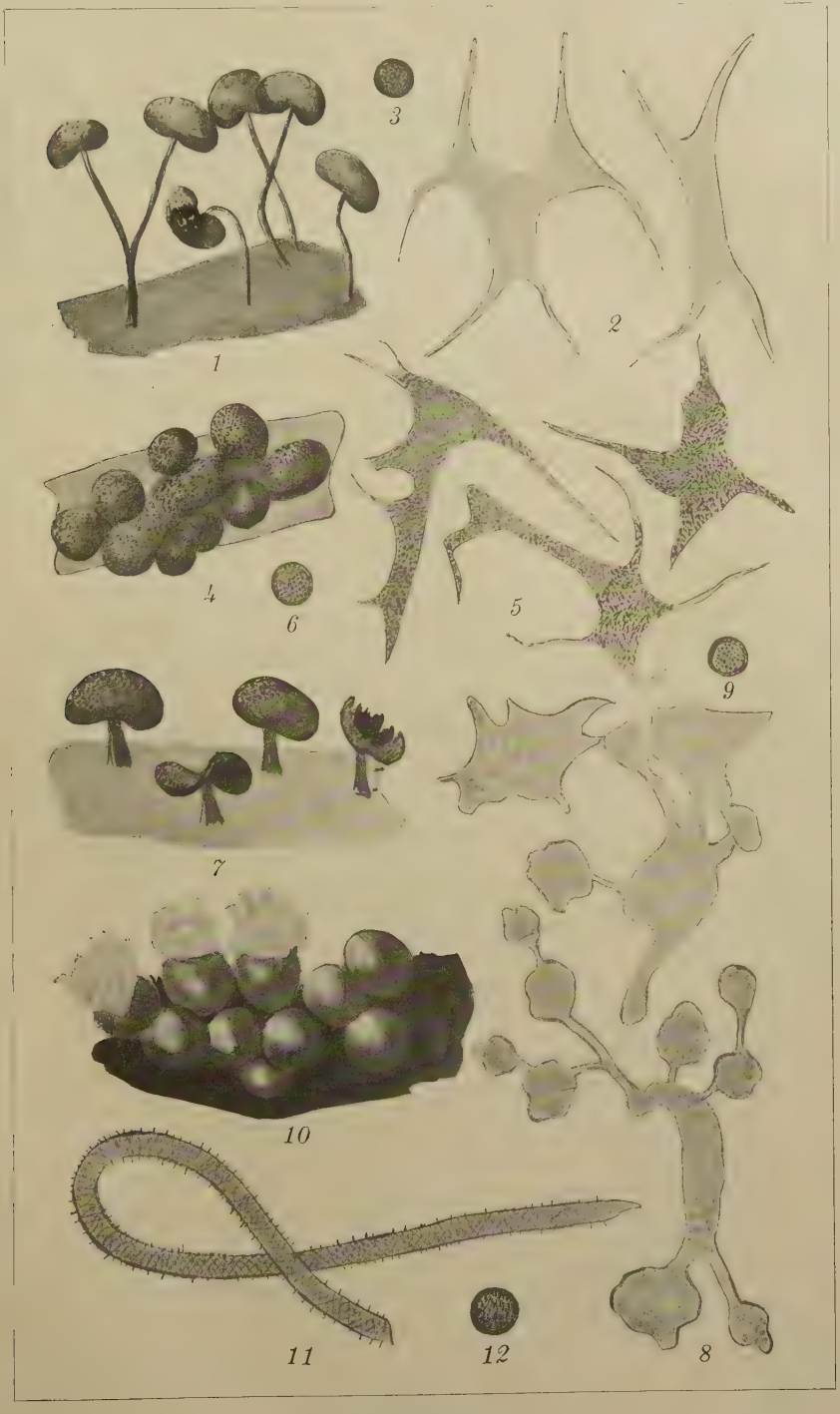


PLATE 1.

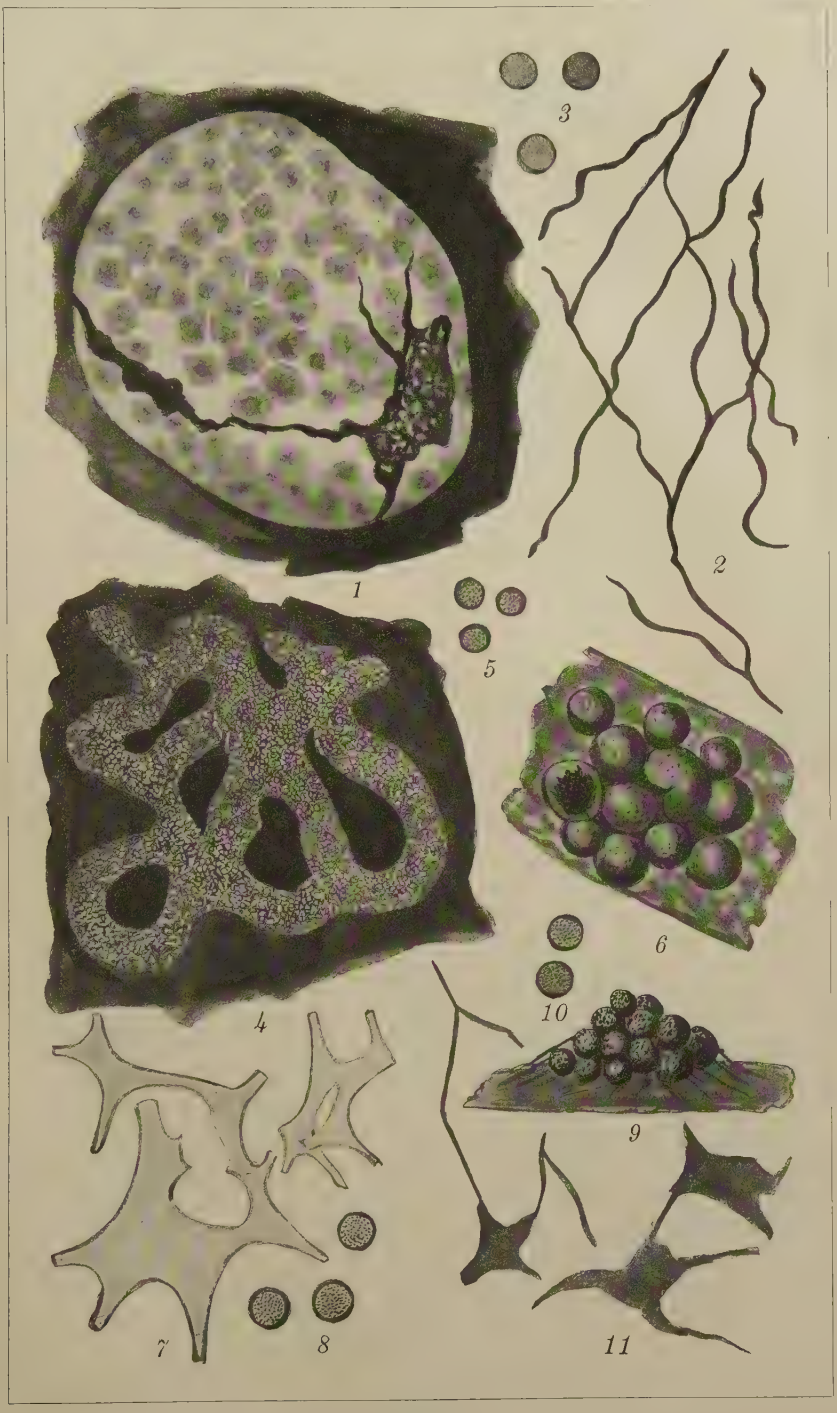
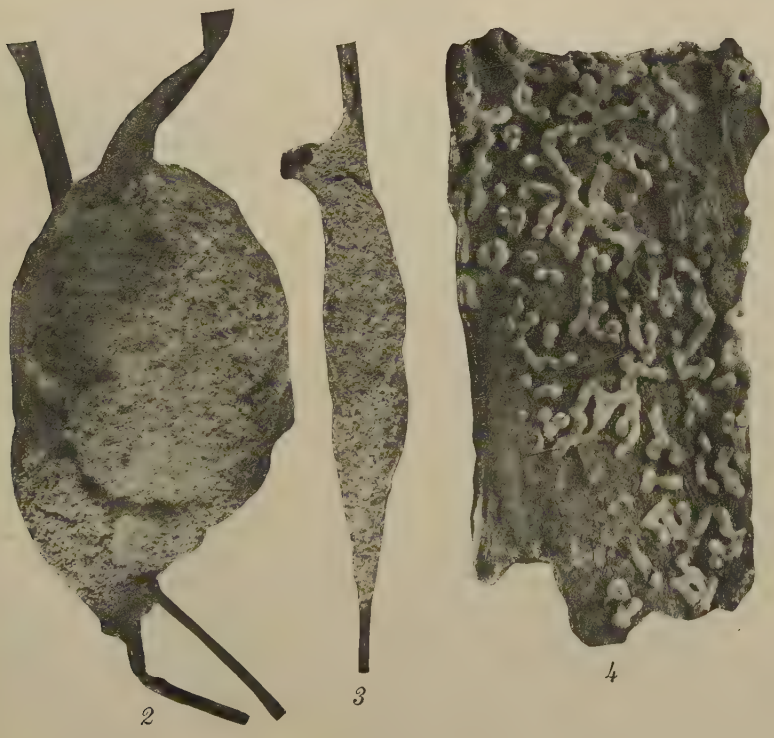


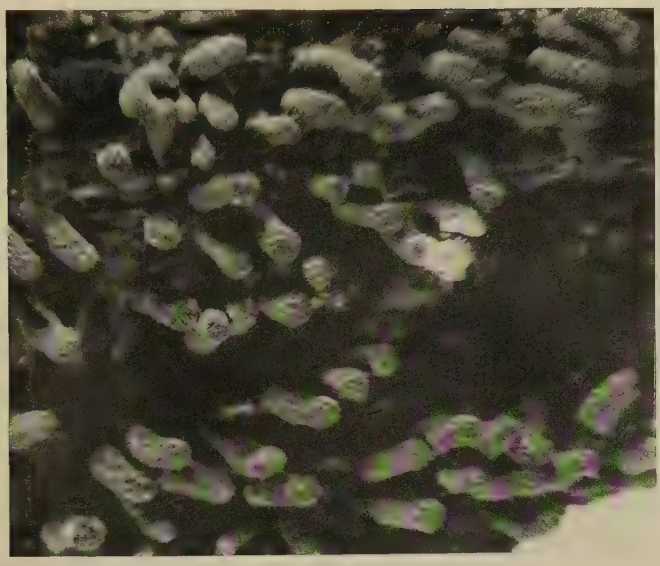
PLATE 2.

1



2 3 4

PLATE 3.



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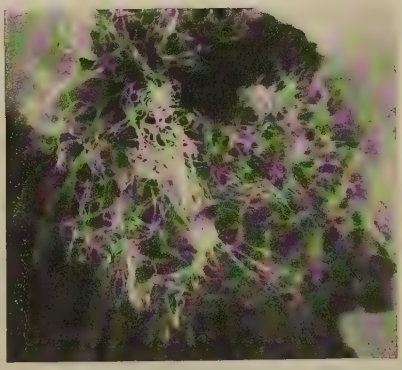

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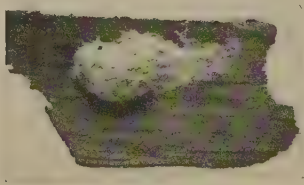

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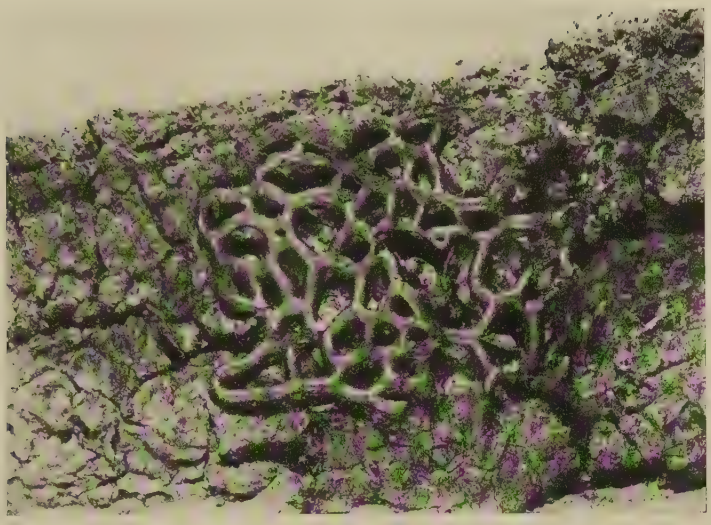
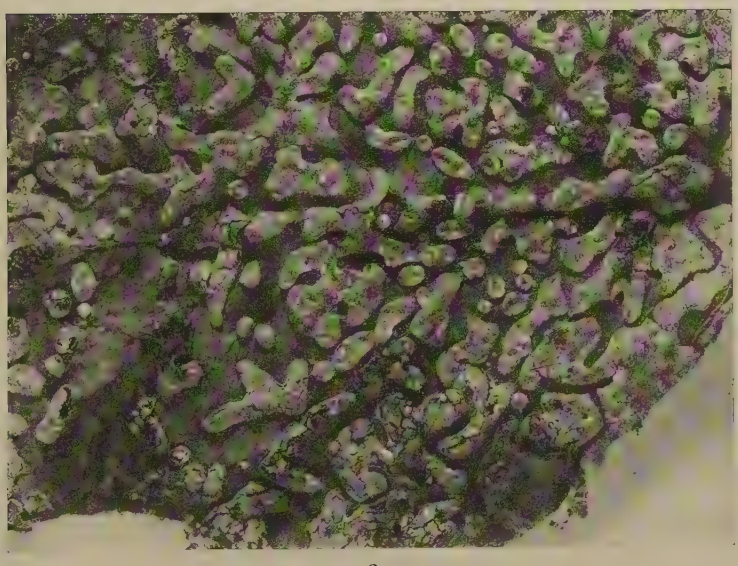
PLATE 4.



1



2

PLATE 5.

PELAGIC DIATOMS OF KOREAN STRAIT OF THE SEA OF JAPAN

By B. W. Skvortzow

Of Harbin, China

TEN PLATES

Our knowledge of pelagic diatoms of the Pacific Ocean is still incomplete in comparison with that of the northern part of the Atlantic. A certain amount of work has been done on the marine diatoms of various parts of Japan, but most of the algæ of the Korean shores have been overlooked. Contributions on the diatoms of the Sea of Japan have been published by K. Okamura, J. Ikari, H. H. Gran, K. Yendo, B. Schroder, and F. Hustedt.

The diatoms that form the subject of this memoir were obtained from material collected by the Government Fishery Experimental Station, of Fusan, Chosen, and sent me through the kindness of Dr. Yojiro Wakiya, director of that station. The gatherings were the following:

1. Fusan, between Katokuto Island and Tatapo, January 12, 1925.
2. Port Fusan, between Fusan and Zetsueito Island, November 9, 1925.
3. Near Port Fusan, February 28, 1926.
4. Northern Tsushima Island, September 13, 1925.
5. Near Tsushima Island, February 3, 1926.

All the samples were rich in pelagic diatoms, especially in *Coscinodiscus, Rhizosolenia, Chaetoceras,* and *Stephanopyxis.* Sample 1 contained *Coscinodiscus* plankton; sample 2, a *Rhizosolenia-Chaetoceras* plankton; sample 3 was very rich in Crustacea and contained some *Coscinodiscus, Eucampia,* and *Stephanopyxis;* sample 4 was the richest in pelagic forms, especially of the genera *Stephanopyxis, Lauderia, Bacteriastrum,* and *Chaetoceras;* sample 5, collected not far from Tsushima Island, contained small *Chaetoceras.*

All these samples yielded a considerable number of diatoms, which I have described and enumerated as a contribution to the geographic distribution of this important group of marine organisms. The present list contains the names of seventy

forms, among which are some new to science. This note is illustrated with drawings by the author. The number or numbers after the comment on each species correspond to the localities given above.

COSCINODISCUS EXCENTRICUS Ehrenberg.

A. SCHMIDT, Atlas Diatom., pl. 58, figs. 46–49; V. HEURCK, Synopsis (1880–85) pl. 130, figs. 4, 7, and 8.

Diameter of valve 0.037 to 0.042 millimeter. Markings polygonal, decreasing towards the border. Apiculi distinct. Geographic distribution: Atlantic and Pacific Oceans and the Sea of Japan. Localities 1, 3, and 4.

COSCINODISCUS FRAGILISSIMUS Grunow.

GRUNOW in V. Heurck, Synopsis (1880–85) pl. 128, fig. 4.

Ethmodiscus convexus CASTRACANE, Diat. Challenger Exped. (1886) 167, pl. 3, fig. 9.

Diameter 0.085 to 0.1 millimeter (in Castracane 0.129, in Grunow 0.316 millimeter). Central space minute, indistinct. Markings forming invisible striations and minute denticules, scattered on the whole surface of the disk. Geographic distribution: Arafura Sea. Locality 1.

COSCINODISCUS CONCINNUS W. Smith. Plate 1, figs. 1–2, 4–6.

A. SCHMIDT, Atlas Diatom. (1886) pl. 114, figs. 8, 9; RATTRAY, Revision Coscin. (1889) 531; PERAGALLO, Diat. Mar. France (1897–1908) pl. 115, fig. 12.

Disk covered with radiating lines of small granules. Diameter of disk 0.13 to 0.37 millimeter. Radiating lines are separated by rows of very minute granules, which pass from as many points, disappear towards the center or form a central rosette. Several valves were found with abnormal areoles, forming a rim in the middle part or two centers. Castracane's *Coscinodiscus papuanus*, from New Guinea, and *Coscinodiscus mirificus* belong to our species. Geographic distribution: Atlantic and Pacific Oceans. Localities 1, 2, 3, and 4.

COSCINODISCUS RADIATUS Ehrenberg. Plate 1, fig. 3.

A. SCHMIDT, Atlas Diatom. pl. 60, figs. 1–6, 9, 10; pl. 61, fig. 13; pl. 65, fig. 8; pl. 113, figs. 8, 21; RATTRAY, Revision Coscin. (1889) 514.

Markings four in 0.01 millimeter, gradually decreasing towards the border. Geographic distribution: Atlantic and Pacific Oceans, Sea of Japan, Hong Kong, Dairen. Localities 1, 2, and 3.

PLANKTONIELLA SOL (Wallich) Schütt. Plate 9, fig. 10.

Schütt, Pflanzenleb. d. Hochsee (1893) 20, fig. 8.
Coscinodiscus sol Wallich, Trans. Micr. Soc. 8 (1860) 38, figs. 1–2.
Cestodiscus sol Grunow in V. Heurck, Synopsis (1880–85) pl. 12, fig. 9; A. Schmidt, Atlas Diatom. (1878) pl. 58, figs. 41, 42, 45; Karsten, Indisch. Phytopl. (1907) 369, pl. 39, figs. 1–12; Hustedt, Kieselalgen (1929) 465–67, fig. 259; Rattray, Revision Coscin. (1889) 466.

Valve flat, disklike. Length 0.052 to 0.12 millimeter. Markings distinct, in radiate rows, decreasing from the center outward. The outer portion of the valve makes a broad, scarcely siliceous disk. Geographic distribution: Common in plankton of Atlantic and Pacific Oceans, Java Sea, Sea of Japan; fossil in Cambridge and Barbados deposits. Locality 4.

ACTINIPTYCHUS UNDULATUS (Bailey) Ralfs.

A. Schmidt, Atlas Diatom. (1874–81) pl. 1, figs. 1–4, 6, 8, 9; pl. 29, figs. 4–8; pl. 109, fig. 1; pl. 122, figs. 1, 3; V. Heurck, Synopsis (1880–85) pl. 122, figs. 1, 3.

Valve disklike. Length 0.025 to 0.09 millimeter. Areoles 3 in 0.01 millimeter. Geographic distribution: Atlantic and Pacific Oceans, Sea of Japan, Dairen. Locality 4.

CORETHRON PELAGICUM Brun. Plate 8, fig. 14.

Schroder, Phytopl. warmer Meere (1906) 343, fig. 3; Hustedt, Kieselalgen (1929) 547, figs. 312*a*, *b*, *c*.

Cell robust, cylindrical, 0.095 to 0.115 millimeter in diameter, with rounded ends and long spines on both sides. Spines very delicate, smooth. Geographic distribution: Atlantic and Pacific Oceans; Hong Kong. Locality 4.

EUCAMPIA ZODIACUS Ehrenberg. Plate 2, figs. 5, 6.

Kützing, Bacillar. (1844) 143, pl. 21, fig. 21; W. Smith, Brit. Diatom. (1853–56) 2, 25, pl. 35, fig. 299; Schütt, Bacillariales (1896) 89, figs. 46A, 147B; Okamura, Littoral Diatoms Japan (1911) 6–7, pl. 11, figs. 33*a–d;* Peragallo, Diat. Mar. France (1897–1908) 376, pl. 95, fig. 2; V. Heurck, Synopsis (1880–85) pl. 95, figs. 17–18.

Cell elliptical forming curved chain. Foramina oval. Geographic distribution: Atlantic and Pacific Oceans; Malay Archipelago; in Japanese waters known from Goza, Toshima, and Boshyu. Localities 1, 2, 3, and 4.

EUCAMPIA BICONCAVA (Cleve) Ostenfeld. Plate 2, fig. 9.

Ostenfeld, Flora Koh Chang, Mar. Plank. Diat. (1902) 23.
Eucampia hemiauloides Ostenfeld in Ostenfeld and Schmidt, Plankton Rode Hav og Adenbugten (1901) 157–58, fig. 8.

Climacodium biconcavum CLEVE, Phytoplank. (1897) 22, pl. 2, figs. 16, 17; OKAMURA, Littoral Diatoms Japan (1911) 8, pl. 11, fig. 35.

C. H. Ostenfeld gives the following description of this alga:

Chain straight, cells slightly siliceous, nearly as long as wide (length 0.04 to 0.06 millimeter, width 0.035 to 0.065); side view elliptic; front view symmetrical on both sides of the longitudinal axis; processes of the valves short; valves membraneous; connecting zone very finely annulated. Chromatophores numerous disciform.

Geographic distribution: Atlantic and Pacific Oceans, Mediterranean and Red Seas, Gulf of Aden, Malay Archipelago; Sea of Japan, Zenidzu. Locality 4.

STEPHANOPYXIS TURRIS (Greville and Arnott) Ralfs. Plate 2, fig. 4.

PRITCHARD, Infusor. (1861) 826, pl. 5, fig. 74; A. SCHMIDT, Atlas Diatom. (1888) pl. 130, figs. 42, 43.

Stephanopyxis appendiculata EHRENBERG, in Microgeol. (1854) pl. 18, fig. 4; HUSTEDT, Kieselalgen (1928) 304–306, fig. 140.

Cell cylindrical, with rounded ends, 0.03 to 0.045 millimeter in breadth and 0.074 to 0.085 in length. The surface is densely cellular. Geographic distribution: Atlantic and Pacific Oceans; known from Japanese waters. Localities 3 and 4.

STEPHANOPYXIS PALMERIANA (Greville) Grunow. Plate 2, figs. 1, 2.

GRUNOW, Diatomeen Franz Josefs-Land (1884) 90.

Stephanopyxis var. *javanica* GRUNOW in A. Schmidt, Atlas Diatom. pl. 130, fig. 44.

Stephanopyxis palmeriana var. *japonica* in OKAMURA, Littoral Diatoms Japan (1911) 2, pl. 8, fig. 2; GRAN and YENDO, Japan. Diatoms (1914) 26–27.

Stephanopyxis campana CASTRACANE, Diat. Challenger Exped. (1886) 88, pl. 19, fig. 14; KARSTEN, Indisch. Phytopl. (1907) pl. 54, figs. 9*a*, *b*; HUSTEDT, Kieselalgen (1928) 308–9, figs. 147*a–d*.

Cells cylindrical, 0.045 to 0.135 millimeter in diameter, forming a long chain. Cells covered with areoles, large in the upper part and small in the middle part of the cell. Geographic distribution: Atlantic and Pacific Oceans. Hong Kong; in Japanese waters known from Shinojima, Shirahama, Goza, Mizaki, Misumi, Yenoshima, Akashi Channel, and Yeddo Bay. Localities 3 and 4.

STEPHANOPYXIS PALMERIANA forma CURTA forma nov. Plate 2, fig. 3.

Valve flat, 0.105 to 0.12 millimeter broad and 0.04 to 0.045 in length. Localities 3 and 4.

THALASSIOSIRA HYALINA (Grunow) Gran. Plate 2, fig. 10.

GRAN, Biblioth. Botan. 42 (1897) 4, pl. 1, figs. 17, 18.

Coscinodiscus hyalinus GRUNOW, Kongl. Sv. Vet. Akad. Handl. 17, No. 2 (1884) 113, pl. 7, fig. 128.

Thalassiosira clevei GRAN, Norske Nordh. Exped. Bot. Protoph. (1897) 29, pl. 4, figs. 60–62; PERAGALLO, Diat. Mar. France (1908) 438, pl. 120, fig. 9.

Thalassiosira gravida CLEVE in Okamura, Littoral Diatoms Japan (1911) 2, pl. 8, fig. 3; HUSTEDT, Kieselalgen (1928) 323–24, fig. 159.

A pelagic diatom forming a long chain composed of flat cells. Our plant has cells 0.045 to 0.052 millimeter in diameter. According to J. Rattray (1889):

Diameter of the valve is 0.025 millimeter. Central space minute, inconspicuous, bearing isolated puncta. Markings punctiform, subequal, 24 in 0.01 millimeter, rows radial to subparallel in inconspicuous fasciculi; apiculi numerous, distinct, in a single circlet. Border broad, hyaline.

Geographic distribution: Atlantic and Pacific Oceans. Locality 4.

LAUDERIA BOREALIS Gran. Plate 2, fig. 11.

GRAN, Nyt. Mag. f. Naturvid. 38 (1900) 110, pl. 2, figs. 5–9.

Lauderia annulata CLEVE, Diatoms of Sea of Java (1873) 8, pl. 1, fig. 7.

Lauderia compressa PERAGALLO, Diatom. Mar. France (1897–1908) pl. 121, fig. 2.

Thalassiosira nordenskioldii CLEVE in Okamura, Littoral Diatoms Japan (1911) 2, pl. 8, fig. 4; HUSTEDT, Kieselalgen (1928) 549–50.

Chain composed of cylindrical frustule, orbicular in side view, near the margin covered with numerous short, hairlike spines. Sculpture consists of very fine puncta. Geographic distribution: Atlantic and Pacific Oceans; in Japanese waters known from Shirahama. Localities 1, 3, and 4.

SCHROEDERELLA DELICATULA (Peragallo) Pavillard. Plate 2, fig. 13.

PAVILLARD, Obser. Diat. (1913) 60, 126.

Lauderia delicatula PERAGALLO, Bull. Soc. Hist. Nat. Toulouse (1888) 22, 81, pl. 6, fig. 46.

Lauderia delicatula PERAGALLO, Diat. Mar. France (1897–1908) pl. 121, figs. 4, 8, 9.

Lauderiopsis costata OSTENFELD, in Ostenfeld and Schmidt, Plankton Rode Hav. og Adenbugten (1901) 158–59, fig. 10.

Detonula schroederi GRAN, Nord. Plankton (1906) 22; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 320, figs. 16–17; pl. 321, fig. 4; Kieselalgen (1929) 551–53, fig. 314.

Chain straight, composed of many cylindrical cells 0.025 to 0.04 millimeter broad, rectangular in front view. Geographic distribution: Common in Atlantic and Pacific Oceans. Locality 4.

LEPTOCYLINDRUS CURVATUS sp. nov. Plate 2, fig. 14.

Cell cylindrical, rectangular in front view, 0.004 to 0.0045 millimeter broad, 0.007 to 0.008 in length. Chromatophores numerous. Locality 4.

DITYLIUM BRIGHTWELLII (West) Grunow. Plate 2, figs. 7, 8.

V. HEURCK, Synopsis (1880–85) pl. 114, figs. 3–9; Traite Diatom. (1889) 424, pl. 17, fig. 606; A. SCHMIDT, Atlas Diatom. pl. 152, figs. 10–13; PERAGALLO, Diatom. Mar. France (1897–1908) 395–96, pl. 96, figs. 6–11; SCHRÖDER, Phytopl. Antarkt. Meeres (1906) 353–55, figs. 22*a–c*.

Ditylium sol V. HEURCK in Okamura, Littoral Diatoms Japan (1911) 8, pl. 11, fig. 37.

A plankton species with a peculiar triangular valve with two long horns from both sides. Geographic distribution: Atlantic and Pacific Oceans; in the Sea of Japan known from Tateyama, Shirahama, Shima, Misaki, and Hong Kong. Localities 2 and 4.

CHAETOCERAS LORENZIANUM Grunow. Plate 3, fig. 4.

GRUNOW, Osterreich. Diatom. (1864) 157, pl. 5, fig. 13; V. HEURCK, Synopsis (1880–85) pl. 82, fig. 2; CLEVE, Diatom. Arctic Sea (1897) 21, pl. 1, figs. 13–15; GRAN, Nord. Plankton (1906) 76, fig. 90; OKAMURA, Chaetoceras and Peragallia (1907) 93, pl. 4, figs. 38–39; Littoral Diatoms Japan (1911) 7, pl. 11, fig. 31.

Chaetoceras cellulosum LAUDER, Diatom. Hong Kong (1864) 78, pl. 8, fig. 12; GRAN and YENDO, Japan. Diatoms (1914) 9; PERAGALLO, Diatom. Mar. France (1897–1908) 484, pl. 131, figs. 1–3; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 321, figs. 18–19; pl. 322, fig. 1.

Cells forming a straight chain 0.008 to 0.012 millimeter broad. Cell rectangular with projecting angles. Foramina large, broad elliptic or quadrangular with round angles. Setæ thin, their basal parts almost parallel to the chain axis. Terminal setæ rather well differentiated and disposed parallel or more or less divergent. Geographic distribution: Atlantic and Pacific Oceans; in Japanese waters known from Boshu, Misaki, Enoshima, Akashi, and Formosa Channel. Localities 2, 4, and 5.

CHAETOCERAS JAVANICUM Cleve. Plate 3, fig. 2.

CLEVE, Diatoms Sea of Java (1873) 11, pl. 2, fig. 13; PERAGALLO, Diatom. Mar. France (1897–1908) 480, pl. 130, figs. 1, 2; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 323, figs. 1, 2.

Cells forming a straight chain 0.02 to 0.04 millimeter broad. From the front view the cell is rectangular with projecting angles. Foramina large, broad elliptic; setæ thin, with their basal parts almost parallel to the chain axis. Terminal setæ parallel or more or less divergent. Chromatophore single.

Geographic distribution: Indian Ocean and Sea of Japan. Localities 2, 4, and 5.

CHAETOCERAS SIAMENSE Ostenfeld. Plate 3, fig. 3.

OSTENFELD, Flora Koh Chang (1902) 21, fig. 17.

Chaetoceras lauderi RALFS var. in Lauder, Diatom. Hong Kong (1864) 77, pl. 8, fig. 3.

Chaetoceras misumense GRAN and YENDO, Japan. Diatoms (1914) 14–15, fig. 7; IKARI, Chaetoceras Japan. (1928) 257–58, fig. 11.

I quote the diagnosis of Gran and Yendo, as follows:

The frustules are quadrangular, measuring 0.02 to 0.03 millimeter in breadth, and 0.02 to 0.04 millimeter in height, and are elliptical in a valvar view. The setae spring directly from the corners of the valves, at first diverging and then gradually bending in a direction parallel to the axis of the chain. Their terminal half is armed with minute spinous processes arranged spirally. The terminal horns have a similar direction to that of the setae, but bent more abruptly near the points of insertion and then run almost straight out, forming an acute angle with one another. The two horns are in one plane. They are more robust than the setae, and like them are beset with minute processes. The foramen is elliptical or broadly lanceolate in a surface view, but practically narrow lanceolate in an optical section. There are two peculiar depressions in the middle of each valve, as shown by Lauder. The girdle-bands become much narrowed about the middle of the complanate side of the frustules. The resting spores have pallisade spines on the margins of both the primary and the secondary valve. The primary valve is almost hemispherical, and has numerous short spines over its whole surface; the secondary valve is nearly similar, but is somewhat humped and has short spines condensed about the summit.

The Korean specimens were without spores. Geographic distribution: Sea of Japan (Kushimoto, Seto, Misumi), South China Sea, Hong Kong. Localities 2 and 5.

CHAETOCERAS BOREALE Bailey. Plate 3, fig. 1.

BAILEY, Notes Microscop. Organ. (1854) 8, figs. 22–23.

Chaetoceras boreale var. *brightwellii* CLEVE, Diat. Arctic Sea (1873) 12, fig. 7*a*.

Chaetoceras boreale CLEVE, Treatise Phytopl. N. Atlantic (1897) 20, pl. 1, fig. 1.

Chaetoceras boreale var. *brightwellii* CLEVE, Treatise Phytopl. N. Atlantic (1897) 20, pl. 1, fig. 2; PERAGALLO, Diatom. Mar. France (1897–1908) 476–77, pl. 127, figs. 2, 3; OKAMURA, Chaetoceras and Peragallia Japan (1907) 90, pl. 3, figs. 18–20; GRAN, Diatom. Arkt. Meere (1904) 533, fig. 5; Nord. Plankton (1906) 73, fig. 87; GRAN and YENDO, Japan Diatom. (1914) 7; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 325, figs. 5, 6.

Chain straight, 0.025 to 0.04 millimeter broad. Cells in front view quadrangular with rounded angles, shorter than the

breadth. Girdle band attains over one-third of the cell height. Valve convex. Foramina small and rhomboidal. Setæ start direct from these cones and each then coalesces with that of the neighboring cell within the lateral sides of the chain. Setæ adorned with spines. Geographic distribution: Common in northern seas, Atlantic and Pacific Oceans; known from Japanese waters from Tateyama and Misaki. Localities 2, 3, and 4.

CHAETOCERAS REICHELTI Hustedt. Plate 7, fig. 2.

HUSTEDT in A. Schmidt, Atlas Diatom. (1921) pl. 344, fig. 6.

Chain straight, composed of 3 or 4 cells, 0.02 to 0.03 millimeter broad. Cells in front view quadrangular, twice longer than breadth. Girdle band about one-half of the mantle height. Setæ long, punctate, issuing from the angles of the valves, crossing each other, leaving short basal parts and diverging at an obtuse angle. Terminal setæ nearly parallel to the chain axis or somewhat divergent from each other. Geographic distribution: See Adler-Hafen collected by Cohn in 1912. Locality 4.

CHAETOCERAS IKARI sp. nov. Plate 7, fig. 1.

Chain straight 0.008 to 0.015 millimeter broad, composed of five to twenty cells. Frustules rectangular elongate, three to four times as long as the breadth, with sharp projecting angles. Valve concave or sometimes flat. Foramina large, broad, elliptic. Setæ thin, issuing from the angles of the valves, diverging at an obtuse angle. Chromatophore single. Named in honor of the well-known Japanese diatomist I. Ikari, Seto Biological Station, Japan. Localities 2 and 4.

CHAETOCERAS SOCIALE Lauder. Plate 5, fig. 7.

LAUDER, Diatom. Hong Kong (1864) 77, pl. 8, fig. 1; CLEVE, Diatoms Baffin Bay (1896) 9, pl. 2, fig. 9; GRAN, Bacillar. Karajakfjord (1897) 26, pl. 4, fig. 54; Nord. Plankton (1906) 96, fig. 123; GRAN and YENDO, Japan. Diatoms (1914) 24; OKAMURA, Littoral Diatoms Japan (1911) 7, pl. 11, fig. 30; PERAGALLO, Diatom. Mar. France (1897–1908) 490, pl. 132, figs. 1–3.

Cells slender, aggregated, embedded in gelatine. Chain composed of three to five cells. Valves broadly oval and flat, in front view rectangular. Setæ very delicate, thin, straight, curved or undulated. The chromatophore single. Geographic distribution: Arctic Sea, Atlantic and Pacific Oceans; known from Japanese waters from Boshu Province, Volcano Bay, Mi-

saki, Otaru Bay, Euoshima, and Akashi. Localities 1, 2, 4, and 5.

CHAETOCERAS PROTUBERANS Lauder. Plate 5, fig. 4.

LAUDER, Diatom. Hong Kong (1864) 79, pl. 8, fig. 11.

Chaetoceras didymum in OKAMURA, Chaetoceras and Peragallia (1907) 95, pl. 4, fig. 45*a*; GRAN and YENDO, Japan. Diatoms (1914) 12–13, fig. 5; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 326, figs. 1, 5.

Cells forming a long chain, 0.005 to 0.008 millimeter broad. Cell oblong with mamilliform protuberance. Setæ long, spinose, coalesced. Terminal setæ well developed, curved, with spirally disposed punctations. Geographic distribution: Atlantic and Pacific Oceans; in Japanese waters known from Shima Province, Misaki, Otaru Bay, and Misumi. Localities 2, 4, and 5.

CHAETOCERAS DIDYMUM Ehrenberg var. ANGLICA Gran. Plate 5, fig. 6.

GRAN, Nord. Plankton, (1906) 80, fig. 95; OKAMURA, Chaetoceras and Peragallia (1907) 95, pl. 4, figs. 44–47, excl. fig. 45*a*; V. HEURCK, Synopsis (1880–85) pl. 82, fig. 3.

Chaetoceras didymum var. *longicruris* CLEVE, Phytopl. (1897) 21, pl. 1, fig. 11; PERAGALLO, Diatom. Mar. France (1897–1908) 481, pl. 128, fig. 3; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 326, figs. 3, 4.

Cells forming a straight chain, 0.025 to 0.03 millimeter broad, sometimes composed of twenty or more cells. Cells quadrangular or elliptical, convex in the middle, forming a large dot. Setæ arise from within the angles curved. Geographic distribution: In Japanese waters found in Shima Province, Misaki, Misumi, Enoshima, and Formosa Channel. Localities 2, 4, and 5.

CHAETOCERAS DIDYMUM Ehrenberg var. GENUINA Gran. Plate 5, figs. 3 and 5.

GRAN, Nord. Plankton (1906) 79, fig. 94; GRAN and YENDO, Japan. Diatoms (1914) 12–13; OKAMURA, Chaetoceras and Peragallia (1907) 95, pl. 4, figs. 44–47, excl. fig. 45*a*; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 326, figs. 2, 7; PERAGALLO, Diatom. Mar. France (1897–1908) 480–81, pl. 128, figs. 1, 2.

Cells forming a straight chain 0.03 to 0.055 millimeter broad, composed of many cells. Cells broad elliptical, convex in the middle. Setæ starting from the angles of the valve, crossing one another close to their insertions, diverging at an obtuse angle. Terminal setæ well developed, robute, straight. Geographic distribution: Atlantic and Pacific Oceans; known from

Japanese waters from Tosa Province, Misumi, Enoshima, and Akashi. Localities 2, 3, 4, and 5.

CHAETOCERAS RADIANS Schütt. Plate 5, fig. 2.

SCHÜTT, Chaetoceras und Peragallia (1895) 41, figs. 10*a–c;* PERAGALLO, Diatom. Mar. France (1897–1908) 490–91, pl. 133, fig. 4; GRAN, North Polar Exped. (1900) 26; Nord. Plankton (1906) 97, fig. 124.

Cell forming a spiral and curved chain, 0.008 to 0.01 millimeter broad. Cell small in front view, rectangular. Foramina oblong or hexagonal. Setæ only on one side, straight, thin. Chromatophore single. Geographic distribution: Atlantic and Pacific Oceans. Localities 4 and 5.

CHAETOCERAS DECIPIENS Cleve. Plate 6, figs. 3 and 4.

CLEVE, Diatoms Arctic Sea (1873) 11, fig. 5; GRAN, Protoph., Diatom., etc. (1897) 13, pl. 1, figs. 2, 3; pl. 3, figs. 3, 4; Diatom. Arkt. Meere (1904) 535–38, pl. 17, figs. 1–6; GRAN and YENDO, Japan. Diatoms (1914) 8–9, figs. 3*a, b;* PERAGALLO, Diatom. Mar. France (1897–1908) 485, pl. 131, figs. 4–8.

Chaetoceras grunowii SCHÜTT, Chaetoceras und Peragallia (1895) 43, figs. 14*a, b.*

Cells forming a straight chain, rectangular in a broader front, with round or somewhat projecting angles. Valves broad elliptic, convex in the middle. Foramina elongate, slightly constricted in the middle. Basal parts of the setæ parallel to chain axis, then parallel or diverging at an obtuse angle. Terminal setæ diverging in a variable angle. The terminal and the lateral setæ are clearly punctated, but in some chains such markings are entirely lacking. Chromatophores numerous. Geographic distribution: Very common in Atlantic and Pacific Oceans; in Japanese waters found at Otaru Bay, Echigo Province, Misumi, and Enoshima. Localities 2, 4, and 5.

CHAETOCERAS COMPRESSUM Lauder. Plate 5, fig. 1.

LAUDER, Diatom. Hong Kong (1864) 78, pl. 8, fig. 6; CLEVE, Plankton. Ciliof. och. Diatom. (1894) 12, pl. 2, fig. 3; SCHÜTT, Chaetoceras und Peragallia (1895) 43, figs. 16, *a, b;* OSTENFELD, Flora Koh Chang (1902) 94, pl. 3, figs. 8–11.

Chaetoceras contortum SCHÜTT, Diatom. Chaetoceras (1888) pl. 3, fig. 4.

Chaetoceras medium SCHÜTT, Chaetoceras und Peragallia (1895) 43, fig. 15; GRAN, Bacillar. Karajakfjord. (1897) 14, pl. 2, fig. 32; GRAN and YENDO, Japan. Diatoms (1914) 10, figs. 4*a–d;* PERAGALLO, Diatom. Mar. France (1897–1908) 488–89, pl. 134, fig. 8.

Chain straight or slightly curved when composed of many cells, 0.016 to 0.024 millimeter broad. Foramina oblong or constricted

in the middle part. Lateral view of valve compressed oval. Setæ arise from a little within the angles, long, robust, with strong undulations and with verrucose dots small and very thin. Geographic distribution: A well-distributed species known from the Sea of Japan, Volcano Bay, Echigo Province, Misaki, Yeddo Bay, Misumi, Tateyama, Enoshima, Akashi, and Formosa Channel. Localities 2, 4, and 5.

CHAETOCERAS TORTISSIMUM Gran. Plate 6, fig. 2.

GRAN, Nord. Plankton (1906) 95–96, fig. 122; PAVILLARD, Danish Ocean. Exped. (1925) 52, fig. 87; IKARI, Chaetoceras of Japan (1928) 532–33, figs. 5*a*, *b*.

Chain straight or curved. Cells in front view rectangular, with some rounded angles. Setæ delicate, thin, smooth, most perpendicular to the chain axis. Chromatophores solitary. Geographic distribution: Atlantic and Pacific Oceans; Sea of Japan at Seto and Oshoro. Locality 5.

CHAETOCERAS ATLANTICUM Cleve. Plate 7, figs. 3–5.

CLEVE, Diat. Arctic Sea (1873) 11, pl. 2, fig. 8; GRAN, Nord. Plankton (1906) 64, fig. 74; GRAN and YENDO, Japan. Diatoms (1914) 3–5, fig. 1; KARSTEN, Phytopl. Antark. Meere (1905–6) 115, pl. 15, fig. 9; OKAMURA, Chaetoceras and Peragallia (1907) 89, pl. 4, figs. 56–62.

Chaetoceras atlanticum var. *tumescens* GRUNOW in V. Heurck. Synopsis (1880–85) pl. 81, fig. 6.

Chaetoceras dispar CASTRACANE, Diatom. Challenger Exped. (1886) 76, pl. 8, fig. 6.

Chaetoceras compactum SCHÜTT, Chaetoceras und Peragallia (1895) 46, fig. 23.

Chaetoceras skeleton SCHRÖDER, Phytopl. warm. Meere (1906) 337.

Chain straight and composed of many cells. Cells in front view quadrangular or, frequently, much compressed; shorter than the breadth. Girdle band about one-third of the mantle height. Setæ long, smooth, curved. Geographic distribution: Atlantic and Pacific Oceans; in Japanese waters known from Tosa, Kuriles, Enoshima, Volcano Bay, and Otaru Bay. Locality 4.

CHAETOCERAS DADAYI Pavillard. Plate 6, fig. 1.

PAVILLARD, Observ. Diatoms (1913) 131–33, fig. 2; Danish Ocean. Exped. (1925) 41, figs. 54*b*; IKARI, Chaetoceras of Japan (1926) 519–20, figs. 2*c*, *d*.

Chain straight, composed of five or more cells, 0.025 to 0.04 millimeter broad. Frustules in front view rectangular with rounded angles. Foramina very narrow or indistinct. Setæ

issuing from the margin, long and thickened, with densely disposed spines. Terminal setæ not differentiated. Chromatophores small, numerous, and passing into the setæ. Geographic distribution: Atlantic and Pacific Oceans, Mediterranean Sea, Sea of Japan, Seto. Locality 4.

CHAETOCERAS PERUVIANUM Brightwell. Plate 4, figs. 4, 5.

BRIGHTWELL, Filam. longhorned Diatom. (1856) 107, figs. 16, 17; CLEVE, Diatoms of Sea of Java (1873) 8, pl. 2, fig. 8; KARSTEN, Phytopl. Antark. Meere (1905) 166, pl. 31, fig. 4; OKAMURA, Chaetoceras and Peragallia (1907) 91, pl. 4, figs. 67–75; PERAGALLO, Diatom. Mar. France (1897–1908) 475, pl. 125, fig. 1.

Peragallia meridiana SCHÜTT, Chaetoceras und Peragallia (1895) 48, figs. 28*a*, *b*.

Cells solitary, or forming a very short filament composed of two to four cells, 0.015 to 0.025 millimeter broad. Cells from front view quadrangular or elongated with rounded angles. The elongated cells have a transversal costation, sometimes zigzag in the middle part. Valve convex. Setæ very robust, straight, curved, covered with solid spines and transversely very thinly striated. Chromatophores small, round, numerous. A chain-forming *Peragallia meridiana* Schütt, Iiro Ikari describes as *Chaetoceras okamurai* Ikari. Geographic distribution: Atlantic, Indian, and Pacific Oceans; in Japanese waters found in Tosa Province, Shima Province, Misaki, Enoshima, Akashi, and Seto. Localities 2, 4, and 5.

CHAETOCERAS SALTANS Cleve. Plate 4, fig. 3.

CLEVE, Phytopl. N. Atlantic (1897) 22, pl. 1, fig. 8; PERAGALLO, Diatom. Mar. France (1897–1908) 476, pl. 126, fig. 1.

Cells solitary, 0.015 to 0.018 millimeter broad, from the front view quadrangular, with rounded angles. Girdle band narrow. Setæ robust and spinulose. Related to *Chaetoceras peruvianum* Brightw. and somewhat to *Chaetoceras criophilum* f. *volans* (Schütt) Gran. Geographic distribution: Atlantic and Pacific Oceans. Locality 4.

CHAETOCERAS AFFINE Lauder. Plate 4, fig. 2.

LAUDER, Diatom. Hong Kong (1864) 78, pl. 8, fig. 5.

Chaetoceras ralfsii CLEVE, Diatoms of Sea of Java (1873) 10, pl. 3, fig. 15.

Chaetoceras ralfsii CLEVE in Karsten, Phytopl. Antarkt. Meere (1906) 168–69, pl. 33, figs. 17–18.

Chaetoceras schüttii CLEVE, Plankton., Ciliof. och Diatom. (1894) 14, pl. 1, fig. 1.

Chaetoceras distichum SCHÜTT, Chaetoceras und Peragallia (1895) 37, figs. 2*a*, *b*.

Chaetoceras angulatum SCHÜTT, Chaetoceras und Peragallia (1895) 37, figs. 1*a–d*.

Chaetoceras procerum SCHÜTT, Chaetoceras und Peragallia (1895) 38, fig. 3*a, b;* PERAGALLO, Diatom. Mar. France (1895–1908) 478–79, pl. 129, fig. 3.

Cells forming a straight chain, 0.015 to 0.024 millimeter broad, composed of five to fifteen cells. Frustules in a broad front quadrangular with somewhat pointed angles. Foramina narrowly lanceolate, slightly constricted in the middle. Setæ all alike, smooth, disposed in a valval view at about right angles with one another. Terminal setæ well developed, curved, hornlike, with minute elevations spirally disposed. Chromatophore is one large plate, parietally in each cell. Resting spores 0.018 to 0.03 millimeter in diameter, primary valve nearly hemispherical with short spines all over the surface. Secondary valve greatly convex with long spines on the middle part.

According to Gran and Yendo, *Chaetoceras affine* is extremely variable in its form and in Japanese waters two types were found, one with rectangular, another with narrow, subcylindrical frustules. The terminal horns are less curved or divergent. Geographic distribution: *Chaetoceras affine* is widely distributed in the warmer parts of the Atlantic, Indian, and Pacific Oceans; in Japanese waters it has been recorded at Boshu Province, Shima Province, Enoshima, Akashi, Yeddo Bay, and Misaki. Localities 2, 4, and 5.

CHAETOCERAS MESSANENSE Castracane. Plate 4, fig. 1.

CASTRACANE, Contrib. Fl. Mediter. (1875) 32, pl. 1, fig. 1.

Chaetoceras sp. in LAUDER, Diatom. Hong Kong (1864) pl. 3, fig. 8.

Chaetoceras furca CLEVE, Phytopl. N. Atlantic (1897) 21, pl. 1, fig. 10.

Chaetoceras furca CLEVE in Karsten, Phytopl. Antark. Meere (1905) 169, pl. 32, figs. 13 *a, b*.

Chaetoceras furca Cleve var. *macroceras* SCHRÖDER in Okamura, Chaetoceras and Peragallia (1907) 99, pl. 3, fig. 7; GRAN, Nord. Plankton (1906) 87, fig. 108; PERAGALLO, Diatom. Mar. France (1897–1908) 488, pl. 129, fig. 1; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 322, figs. 4 and 7; pl. 325, fig. 3.

Chain straight, 0.011 to 0.028 millimeter wide and 0.1 to 0.15 in length. Cells in front view rectangular with projecting angles, valves concave, foramina lanceolate. Girdle band rather longer than about a half of the cell height. Setæ of two types. One type is thin, short, starting from the angles of the valve, crossing one another close to their insertions, diverging at an obtuse angle. The other is robust, furcate at the end with

spirally disposed punctations. Terminal setæ not differentiated, short, simple. Chromatophore solitary. Locality 5.

BACTERIASTRUM VARIANS Lauder. Plate 8, figs. 1, 3, 5–7.

LAUDER, Diatom. Hong Kong (1864) 6, figs. 1–5; KARSTEN, Phytopl. Antark. Meere (1905) 170, pl. 34, fig. 1; PERAGALLO, Diatom. Mar. France (1897–1908) 470, pl. 136, fig. 1–5.

Chaetoceras varians (Lauder) V. HEURCK, Synopsis (1880–85) 195, pl. 70, figs. 3–5.

Bacteriastrum spirillum CASTRACANE, Diatom. Challenger Exped. (1886) 83, pl. 19, fig. 2; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 328, figs. 1–5 and 11; IKARI, Bacteriastrum of Japan (1927) 421–22, fig. 1.

Chain straight, composed of many cells. Frustules cylindrical, with ten to fourteen furcated setæ covered with thin undulations. Terminal horns ten, curved at the ends and covered with spiral markings. Geographic distribution: Atlantic and Pacific Oceans; known from the Japanese waters of Oshoro, Hakodate, Seto, Kushimoto, Takashima, and Goza. Localities 2, 3, and 5.

BACTERIASTRUM HYALINUM Lauder. Plate 8, fig. 2.

LAUDER, Diatom. Hong Kong (1864) 6, pl. 3, figs. 7*a*, *b*.

Bacteriastrum spirillum CASTRACANE, Diatom. Challenger Exped. (1886) 83, pl. 24, fig. 1.

Bacteriastrum varians var. *hyalina* LAUDER in Peragallo, Diatom. Mar. France (1897–1908) 470, pl. 136, fig. 6; PAVILLARD, Observ. Diatoms (1916) 27, pl. 1, fig. 4; Danish Oceanogr. Exped. (1925) 37, fig. 58; IKARI, Bacteriastrum of Japan (1927) 422–23, fig. 2.

According to Ikari this species has—

Chain straight and composed of many cells. Foramina not very large. Length of the cell is about equal to, but generally a little shorter than the breadth (diameter 0.013 to 0.056 millimeter). Setæ, from 7 to 25 in number. Intermediate ones unite one another to form radial rays of nearly equal length to or at least a half of the diameter of the cell. The mode of bifurcation is greatly different from the preceding species; the plane which involves the furcated parts, is placed parallel to the chain axis, giving a very spiny appearance to the chain. The terminal horns are gradually curved and bent downwards, and show spiral undulations on them. Chromatophores numerous and small, the resting nucleus is situated in the center of the cell.

Geographic distribution: Atlantic and Pacific Oceans, Sea of Japan, Seto, Kushimoto, Enoshima, and Akashi. Localities 2, 4, and 5.

BACTERIASTRUM MINUS Karsten. Plate 8, fig. 4.

KARSTEN, Phytopl. Antark. Meere (1905) 171, pl. 33, fig. 21.

Bacteriastrum hyalinum LAUDER in Okamura, Littoral Diatoms Japan (1911) 6, pl. 10, fig. 28; IKARI, Bacteriastrum of Japan (1927) 426–27, fig. 6.

Chain straight, composed of many cells. Frustules disklike, 0.018 to 0.025 millimeter in diameter. Intermediate and terminal setæ short and delicate, directed obliquely outwards to the chain axis. Geographic distribution: Atlantic and Pacific Oceans; in Japanese waters known from Oshoro, Hakodate, Tateyama, Kashimoto, Seto, Takashima, and Goza. Locality 4.

BACTERIASTRUM COMOSUM Pavillard var. HISPIDA (Castracane) Ikari. Plate 8, fig. 8.

IKARI, Bacteriastrum of Japan (1927) 428–29, fig. 8*b*.

Bacteriastrum wallichi Ralfs. var. *hispida* CASTRACANE, Diatom. Challenger Exped. (1886) 83, pl. 29, fig. 6.

Bacteriastrum varians Lauder var. *hispida* (Castr.) SCHRÖDER in Schröder, Phytopl. Warm. Meere (1906) 347, fig. 11.

Bacteriastrum varians var. *hispida* in OKAMURA, Littoral Diatoms Japan (1911) 7, pl. 10, figs. 29 *f–g;* HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 328, fig. 12.

Chain straight, composed of many cells. Frustules cylindrical, valve flat. Intermediate setæ long, furcate, curved. Terminal setæ distinct, robust, hornlike, undulated and covered with short spines. Geographic distribution: Atlantic and Pacific Oceans, Sea of Japan, Seto, and Kushimoto. Localities 2 and 4.

BIDDULPHIA SINENSIS Greville. Plate 8, fig. 9.

GREVILLE, Trans. Micr. Soc. (1866) 81, pl. 9, fig. 16; OSTENFELD and SCHMIDT, Plank. Rode Hav og Adenbugten (1901) 152, fig. 6; Flora Koh Chang (1902) 25, fig. 21; CLEVE, Diatoms of Sea of Java (1873) 6; A. SCHMIDT, Atlas Diatom. (1888) pl. 122, figs. 22, 23, 24; LEUDUGER-FORTMOREL, Diatomees Malaisie (1892) 39.

A large pelagic *Biddulphia* with very fine striation. Valve robust, 0.2 to 0.27 millimeter broad and 0.5 to 0.7 millimeter in length. Geographic distribution: Red Sea, Malay Archipelago, Java Sea, South China Sea, Norway, and Sea of Japan. Locality 4.

BIDDULPHIA AURITA Brébisson var. ORIENTALIS Mereschkowsky.

MERESCHKOWSKY, Polynesian Diatoms (1900–1902) 119; A. SCHMIDT, Atlas Diatom. pl. 120, figs. 5, 6; SKVORTZOW, Marine Diatoms Dairen (1929) 420; Marine Diatoms Siberian Shore (1929) 59, fig. 15.

Frustules without spines, 0.042 to 0.051 millimeter in length and 0.018 to 0.037 in breadth. Geographic distribution: Com-

mon in littoral zone in Pacific and Atlantic Oceans, Polynesian, Sea of Japan, and Bay of Bengal. Localities 1 and 2.

BIDDULPHIA PULCHELLA Gray. Plate 2, fig. 12.

W. SMITH, Brit. Diatom. (1853–56) pl. 44, fig. 321; A. SCHMIDT, Atlas Diatom., pl. 118, figs. 26–33; V. HEURCK, Synopsis (1880–85) pl. 97, figs. 1–3; PERAGALLO, Diatom. Mar. France (1897–1908) 376–77, pl. 93, figs. 1, 2.

Biddulphia biddulphiana (Smith) BOYER in Okamura, Littoral Diatoms Japan (1911) 9, pl. 12, fig. 42.

A cosmopolitan diatom, forming a straight chain composed of robust triangular frustules. The length and the breadth of the cells vary from 0.045 to 0.105 millimeter. Geographic distribution: Common in the littoral zone and sometimes in plankton. Atlantic and Pacific Oceans; environs of Vladivostok and Dairen. Localities 1 and 2.

BIDDULPHIA LONGICORNIS Greville. Plate 2, fig. 16.

A. SCHMIDT, Atlas Diatom. pl. 118, fig. 10; OKAMURA, Littoral Diatoms Japan (1911) 11, pl. 12, fig. 46.

Valve seen in face view broadly elliptical, with pointed ends forming an obtuse angle, in which, close to the apices, arise two long horns. Valve ornamented with rows of beads running longitudinally along the valve. In side or girdle view each valve shows two very long outwardly curving horns and two long spines in the middle part of the ends. Girdle broad and curved with closely set rows of transverse beading. Length of the valve 0.066 to 0.075 millimeter, breadth 0.074 to 0.085 millimeter. Geographic distribution: Pacific Ocean. Locality 4.

THALASSIOTHRIX ANTARCTICA Schimper forma JAPONICA forma nov. Plate 9, figs. 1 and 2.

Valve straight, linear, apices slightly produced. Length, 1.6 to 1.95 millimeters; breadth, 0.0055 to 0.0075. Striæ fifteen in 0.01 millimeter. Our form differs from the typical *T. antarctica* by its straight valve. Geographic distribution: Atlantic and Pacific Oceans. Locality 4.

THALASSIOTHRIX NITZSCHIOIDES Grunow. Plate 8, figs. 10 and 11.

V. HEURCK, Synopsis (1880–85) pl. 43, fig. 7.

Synedra nitzschioides GRUNOW, Österreich. Diatom. (1862) 403, pl. 5, fig. 18.

Thalassiothrix curvata CASTRACANE, Diatom. Challenger Exped. (1886) 55, pl. 24, fig. 6.

Thalassiothrix frauenfeldi CLEVE, Plankton., Ciliof., och Diatom. (1894) 6.

Thalassiothrix frauenfeldi var. *nitzschioides* in JÖRGENSEN, Protophyten und Protozoen Plankt. (1900) 20; PERAGALLO, Diatom. Mar. France (1897–1908) 320, pl. 131, figs. 17, 18.

Cells forming star-shaped or zigzag clusters. Cells linear, 0.037 to 0.06 millimeter in length, 0.0025 to 0.006 in breadth; striæ 11 in 0.01 millimeter. Geographic distribution: Atlantic and Pacific Oceans; known from Japan, Eastern and South China Seas. Localities 2, 4, and 5.

THALASSIOTHRIX NITZSCHIOIDES var. JAVANICA Grunow. Plate 9, fig. 6.

V. HEURCK, Synopsis (1880–85) pl. 98, figs. 11, 12.

Cells lanceolate, with slightly elongated, rounded apices. Length, 0.042 to 0.055 millimeter; breadth, 0.0042 to 0.055; striæ marginal, 9 to 10 in 0.01 millimeter. Geographic distribution: Java Sea. Locality 4.

THALASSIOTHRIX FRAUENFELDII Grunow. Plate 9, fig. 8.

CLEVE and GRUNOW, Arkt. Diatom. (1880) 109.

Asterionella frauenfeldii GRUNOW, Verhandl. Zool.-Bot. Gesellsch. (1863) 140, pl. 14.

Asterionella frauenfeldii GRUNOW, Novara Algen (1867) 4.

Asterionella synedraeformis GREVILLE, Ann. Nat. Hist. (1865) 4, pl. 5, figs. 5, 6.

Thalassiothrix frauenfeldii (Grunow) CASTRACANE, Diatom. Challenger Exped. (1886) 54–55, pl. 14, figs. 7, 8; PERAGALLO, Diatom. Mar. France (1897–1908) 321, pl. 131, fig. 15.

Cell linear, 0.22 to 0.29 millimeter in length, 0.004 to 0.005 in breadth, forming large star-shaped clusters. Geographic distribution: Atlantic and Pacific Oceans, Sea of Japan, Eastern and South China Seas. Localities 4 and 5.

ASTERIONELLA JAPONICA Cleve. Plate 9, fig. 9.

GRAN, Nord. Plankton (1906) 118, fig. 160.

Asterionella glacialis CASTRACANE, Diatom. Challenger Exped. (1886) 50, pl. 14, fig. 1; SCHRÖDER, Phytopl. Warm. Meere (1906) 330–37; OKAMURA, Littoral Diatoms Japan (1911) 11, pl. 13, fig. 56.

Length of valve, 0.11 to 0.205 millimeter; breadth on one end, 0.003, on the other end, 0.018. Geographic distribution: Antarctic, Atlantic, and Pacific Oceans; in Japanese waters known from Shira-hama, Misaki, and Shima. Localities 2, 4, and 5.

GRAMMATOPHORA JAPONICA Grunow. Plate 10, fig. 13.

GRUNOW in V. Heurck, Synopsis (1880–85) pl. 103, fig. 18; PERAGALLO, Diatom. Mar. France (1897–1908) 358, pl. 137, fig. 26.

Valve 0.052 to 0.06 millimeter in length, 0.028 to 0.03 in breadth; striæ 28 in 0.01 millimeter. Geographic distribution: Pacific Ocean, Sea of Japan, Dairen. Localities 1 and 2.

GRAMMATOPHORA MARINA (Lyngby) Kützing. Plate 2, fig. 15.

KÜTZING, Bacillar. (1844) 128, pl. 17, fig. 24; W. SMITH, Brit. Diatom. (1853–56) 11, 42, pl. 42, fig. 314; SCHÜTT, Bacillar. (1896) 106, figs. 187, A–B; PERAGALLO, Diatom. Mar. France (1897–1908) 353, pl. 137, figs. 6–8.

Cell 0.021 to 0.027 millimeter in length, 0.017 to 0.02 in breadth; striæ 22 in 0.01 millimeter. Geographic distribution: Atlantic and Pacific Oceans, Mediterranean Sea, Sea of Japan, Vladivostok, and Dairen.

SYNEDRA AURICULATA Karsten. Plate 10, fig. 2.

KARSTEN, Phytopl. Atlant. Ocean (1906) 173, pl. 30, figs. 18*a*, *b*.

Valve linear, straight, 0.8 to 1.2 millimeters in length, 0.006 in breadth. The ends inflated and shortly rounded, striæ 15 in 0.01 millimeter. Geographic distribution: Atlantic Ocean. Locality 4.

SYNEDRA KOREANA sp. nov. Plate 9, figs. 3, 4, and 5.

Valve straight, lanceolate or linear, inflated in the middle part forming a broad lanceolate pseudoraphe. Ends inflated, prolonged into rostrate apices. Length, 2.22 to 2.56 millimeters; breadth in the middle, 0.011 to 0.013; striæ, 10 in 0.01 millimeter. Localities 4 and 5.

NAVICULA PELLUCIDA Karsten. Plate 9, figs. 11 and 12.

KARSTEN, Phytopl. Antarkt. Meere (1905) 126, pl. 18, fig. 3.

Valve elliptic with elongated rounded ends. Length, 0.088 to 0.115 millimeter; breadth, 0.029 to 0.04; median line with the terminal fissures indistinct. Axial area also indistinct; central small. Striæ 20 to 28 in 0.01 millimeter, obscure, thin. This diatom should not be confused with the later-named *N. pellucida* Cleve. Localities 2, 4, and 5.

NAVICULA (CISTULA) LORENZIANA Grunow. Plate 8, fig. 16.

GRUNOW, Oster. Diatom. (1860) 547, pl. 3, fig. 3; CLEVE, Synopsis Nav. Diatom. (1894) 124; PERAGALLO, Diatom. Mar. France (1897–1908) pl. 7, fig. 6; A. SCHMIDT, Atlas Diatom., pl. 212, figs. 51–56.

Valve broad, rectangular. Striæ composed of elongated puncta 15 to 18 in 0.01 millimeter. Rows of puncta 7 in 0.01 millimeter. Length of valve, 0.04 to 0.05 millimeter; breadth, 0.019 to 0.02. Geographic distribution: Littoral zone of England, Balearic Islands, Adriatic, Campeche Bay, Port Jackson, Yokohama. Locality 4.

NAVICULA (SCHIZONEMA) RAMOSISSIMA Agardh forma AMPLIA Grunow. Plate 10, fig. 3.

Schizonema amplius V. HEURCK, Synopsis (1880–85) pl. 15, fig. 3; PERAGALLO, Diatom. Mar. France (1897–1908) pl. 12, fig. 9.

Valve linear-lanceolate with obtuse ends. Length, 0.064 to 0.07 millimeter; breadth, 0.012 to 0.017; striæ, 12 in 0.01 millimeter. Geographic distribution: Atlantic and Pacific Oceans, a benthonic species. Localities 1 and 2.

NAVICULA (SCHIZONEMA) MOLLIS W. Smith. Plate 8, fig. 15.

W. SMITH, Brit. Diatom. (1853–56) 11, 77, pl. 58, fig. 365; V. HEURCK, Synopsis (1880–85) pl. 15, figs. 22, 23.

Schizonema albicans V. HEURCK, Synopsis, pl. 15, fig. 20.

Schizonema torquatum V. HEURCK, Synopsis, pl. 15, fig. 21.

Valve lanceolate, obtuse; length, 0.028 to 0.03 millimeter; breadth, 0.008 to 0.009; striæ, 18 in 0.01. Geographic distribution: Arctic America, Cape Sabine, Bahuslan, North Sea, Adriatic. Localities 1 and 2.

NAVICULA KARIANA Grunow var. MINOR Grunow forma JAPONICA forma nov. Plate 8, fig. 12.

Valve broadly lanceolate with rostrate ends. Length, 0.023 to 0.027 millimeter; breadth, 0.009; striæ, 18 to 20 in 0.01 millimeter. The typical *Navicula kariana* Grunow [1] and var. *minor* Grunow [2] and var. *minor* Grunow forma *curta* Cleve [3] are known from Franz Josef Land, Sea of Kara, Cape Wankarema, Davis Strait, and Cape Deschnew. Locality 1 .

PLEUROSIGMA LONGUM Cleve var. INFLATA Peragallo forma JAPONICA forma nov. Plate 10, fig. 15.

Valve lanceolate, sigmoid, acute. Length, 0.136 to 0.15 millimeter; breadth, 0.017 to 0.02; striæ, 17 in 0.01 millimeter. Geographic distribution: The typical var. *inflata* is known from the Mediterranean. Locality 4.

PLEUROSIGMA WANSBECKII Donkin. Plate 10, fig. 14.

Pleurosigma balticum var. *wansbeckii* DONKIN in Peragallo, Diatom. Mar. France (1890–91) 19, pl. 7, figs. 23, 24.

Valve linear. Length, 0.119 to 0.2 millimeter; breadth, 0.015 to 0.02. Geographic distribution: Sea of Kara and North Sea. Locality 4.

[1] Arct. Diatom., 39, pl. 2, fig. 44.

[2] Arct. Diatom., 5; = *N. frigida* Grunow in Arct. Diatom., 39.

[3] Diatom. Exped. Vega (1883) 469, pl. 37, fig. 40.

GUINARDIA FLACCIDA (Castracane) Peragallo. Plate 2, fig. 17.

PERAGALLO, Diatomiste 1 (1892) 107, pl. 13, figs. 3, 4.

Rhizosolenia flaccida CASTRACANE, Diatom. Challenger Exped. (1886) 74, pl. 29, fig. 4.

Henseniella baltica SCHÜTT in De Toni, Sylloge Algarum (1894) 1425.

Guinardia baltica SCHÜTT, Bacillar. (1896) 84, fig. 138; OKAMURA, Littoral Diatoms Japan (1911) 4, pl. 9, fig. 15; HUSTEDT, Kieselalgen (1929) 561–64, fig. 322.

Cell cylindrical, from 0.023 to 0.07 millimeter broad and two to three times as long as broad, forming a long straight chain. Chromatophores numerous, cross-shaped. Geographic distribution: Atlantic and Pacific Oceans, Mediterranean Sea, and Sea of Japan. Localities 2, 4, and 5.

RHIZOSOLENIA ALATA Brightwell. Plate 10, figs. 9 and 10.

BRIGHTWELL, Quar. Journ. Micr. Sc. 6 (1858) 96, pl. 5, fig. 8; PERAGALLO, Monogr. Rhizosol. (1892) 20, pl. 5, fig. 11; Diatom. Mar. France (1897–1908) pl. 18, fig. 11; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 317, figs. 1–7; HUSTEDT, Kieselalgen (1929) 600; OKAMURA, Littoral Diatoms Japan (1911) 6, pl. 9, fig. 27.

Cell 0.17 to 0.4 millimeter in length and 0.011 to 0.013 in breadth. Geographic distribution: Atlantic and Pacific Oceans; common in Japanese waters and known from Cape Goza, Shirahama, Province of Tosa, and Mikawa. Localities 2 and 4.

RHIZOSOLENIA ALATA Brightwell forma GRACILLIMA (Cleve) Grunow. Plate 10, figs. 11 and 12.

V. HEURCK, Synopsis (1880–85) pl. 79, fig. 8.

Rhizosolenia (*alata* var.) *gracillima* CLEVE, Kongl. Sv. Vet.-Akad. Handl. 18 (1881) 26, pl. 6, fig. 78; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 317, figs. 8–10; HUSTEDT, Kieselalgen (1929) 601, fig. 345.

Cells about 0.006 to 0.0074 millimeter in breadth and 0.2 to 0.85 in length. Geographic distribution: Atlantic, Pacific, and Indian Oceans, Mediterranean and Red Seas, Malay Archipelago, New Zealand, Sea of Japan. Localities 2, 4, and 5.

RHIZOSOLENIA SETIGERA Brightwell. Plate 10, fig. 5.

BRIGHTWELL, Quar. Journ. Micr. Sc. 6 (1858) pl. 5, fig. 4; V. HEURCK, Synopsis (1880–85) pl. 78, figs. 7, 8.

Rhizosolenia japonica CASTRACANE, Diatom. Challenger Exped. (1886) 23, fig. 7; PERAGALLO, Monogr. Rhizosol. (1892) 17, pl. 4, figs. 12–16; Diatom. Mar. France (1897–1908) 464, pl. 124, figs. 11–15; OKAMURA, Littoral Diatoms Japan (1911) 5, pl. 9, fig. 22; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 320, figs. 6–8.

Valve linear, slightly siliceous, 0.75 to 0.9 millimeter in length, 0.01 to 0.014 in breadth with structure hardly visible. Spine long, thin; 0.12 to 0.14 millimeter in length. Geographic

distribution: Atlantic, Pacific, and Indian Oceans, Mediterranean and Red Seas, Malay Archipelago, Sea of Japan. Localities 2, 4, and 5.

RHIZOSOLENIA ROBUSTA Norman. Plate 10, fig. 4.

PRITCHARD, Histor. Infusor. (1861) 866, pl. 8, fig. 42.

Rhizosolenia sigma SCHÜTT, Pflanzenleb. d. Hochsee (1893) 22, fig. 2; PERAGALLO, Monogr. Rhizosol. (1892) 14, pl. 2, fig. 1; pl. 3, figs. 1, 2; Diatom. Mar. France (1897–1908) pl. 123, figs. 1, 2; KARSTEN, Indische Phytopl. (1907) 163, pl. 29, fig. 10; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 320, figs. 1–3; Kieselalgen (1929) 578–80, fig. 330; OKAMURA, Littoral Diatoms Japan (1911) 4, pl. 9, fig. 18.

Cell robust, 0.13 to 0.22 millimeter in breadth, 0.5 to 0.7 in length. The end is curved, contracted, pointed. Geographic distribution: Indian and Pacific Oceans, Mediterranean and Red Seas, Malay Archipelago, Sea of Japan. Localities 2, 4, and 5.

RHIZOSOLENIA HYALINA Ostenfeld. Plate 10, figs. 6, 7, and 8.

OSTENFELD and SCHMIDT, Plankt. Rode Hav Og Adenbugten (1901) 160–61, fig. 11; HUSTEDT in A. Schmidt, Atlas Diatom. (1920) pl. 319, figs. 11–13.

According to Cleve the original diagnosis of this diatom is as follows:

Frustule very slightly siliceous (length 0.28 to 0.34 millimeter, width 0.028 to 0.032); structure hardly visible, squamate (4–5 squamae at the same height); spine (0.032 to 0.04 millimeter long) very thin, slowly incrassated at the base; valve in a front view with a characteristic undulation, of the contour and with a fissure, in which the spine of the neighbour cell is fastened.

Geographic distribution: Red Sea, Japan (Binn-meer bei Akashi, r.m. by Hustedt). Locality 4.

NITZCHIELLA LONGISSIMA (Brébisson) Ralfs forma TYPICA V. Heurck. Plate 10, fig. 1.

Nitzschia birostrata SMITH, Brit. Diatom. 1 (1853–56) 42, pl. 14, fig. 117; V. HEURCK, Synopsis (1880–85) pl. 70, figs. 1–2; Traite Diatom. (1899) 404, pl. 17, figs. 568.

Valve with long horns, 0.5 to 0.7 millimeter in length. Geographic distribution: A cosmopolitan diatom known in many places. Localities 1 and 2.

NITZCHIELLA LONGISSIMA (Brébisson) Ralfs forma PARVA V. Heurck. Plate 9, fig. 7.

V. HEURCK, Synopsis (1880–85) pl. 70, fig. 3; Traite Diatom. (1899) 404, pl. 17, fig. 568; PERAGALLO, Diatom. Mar. France (1897–1908) 293, pl. 124, figs. 16–18.

A delicate diatom, 0.29 to 0.3 millimeter in length and 0.009 in breadth. Geographic distribution: Atlantic and Pacific

Oceans, in littoral zone in benthos and plankton. Localities 1, 2, and 5.

SURIRELLA GEMMA Ehrenberg var. OVATA var. nov. Plate 8, fig. 13.

Valve broad ovate. Length, 0.068 to 0.072 millimeter; breadth, 0.037 to 0.04. Costæ 3 in 0.01 millimeter. Typical *Surirella gemma*[4] have more-elongated valves. Geographic distribution: Atlantic and Pacific Oceans in littoral zone and in plankton. Localities 1 and 2.

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[4] Figured in A. Schmidt, Atlas Diatom. pl. 24, figs. 26–27, and in V. Heurck, Synopsis pl. 74, pls. 1–3.

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ILLUSTRATIONS

Plate 1

Figs. 1 and 2. *Coscinodiscus concinnus* W. Smith.
Fig. 3. *Coscinodiscus radiatus* Ehrenb.
4. *Coscinodiscus concinnus* W. Smith, an abnormal valve.
Figs. 5 and 6. *Coscinodiscus concinnus* W. Smith. The middle parts of the valves greatly enlarged.

Plate 2

Figs. 1 and 2. *Stephanopyxis palmeriana* (Grev.) Grun.
Fig. 3. *Stephanopyxis palmeriana* forma *curta* forma nov.
4. *Stephanopyxis turris* (Grev. and Arn.) Ralfs.
Figs. 5 and 6. *Eucampia zodiacus* Ehrenb.
7 and 8. *Ditylium brightwellii* (West) Grun.
Fig. 9. *Eucampia biconcava* (Cleve) Ostenf.
10. *Thalassiosira hyalina* (Grun.) Gran.
11. *Lauderia borealis* Gran.
12. *Biddulphia pulchella* Gray.
13. *Schroederella delicatula* (Per.) Pavil.
14. *Leptocylindrus curvatus* sp. nov.
15. *Grammatophora marina* (Lyngb.) Kütz.
16. *Biddulphia longicornis* Grev.
17. *Guinardia flaccida* (Castr.) Per.

Plate 3

Fig. 1. *Chaetoceras boreale* Bail.
2. *Chaetoceras javanicum* Cleve.
3. *Chaetoceras siamense* Ostenf.
4. *Chaetoceras lorenzianum* Grun.

Plate 4

Fig. 1. *Chaetoceras messanense* Castr.
2. *Chaetoceras affine* Lauder.
3. *Chaetoceras saltans* Cleve.
Figs. 4 and 5. *Chaetoceras peruvianum* Brightw.

Plate 5

Fig. 1. *Chaetoceras compressum* Lauder.
2. *Chaetoceras radians* Schütt.
3. *Chaetoceras didymum* Ehrenb. var. *genuina* Gran.
4. *Chaetoceras protuberans* Lauder.
5. *Chaetoceras didymum* Ehrenb. var. *genuina* Gran.
6. *Chaetoceras didymum* Ehrenb. var. *anglica* Gran.
7. *Chaetoceras sociale* Lauder.

PLATE 6

FIG. 1. *Chaetoceras dadayi* Pavil.
2. *Chaetoceras tortissimum* Gran.
FIGS. 3 and 4. *Chaetoceras decipiens* Cleve.

PLATE 7

FIG. 1. *Chaetoceras ikari* sp. nov.
2. *Chaetoceras reichelti* Hustedt.
FIGS. 3, 4, and 5. *Chaetoceras atlanticum* Cleve.

PLATE 8

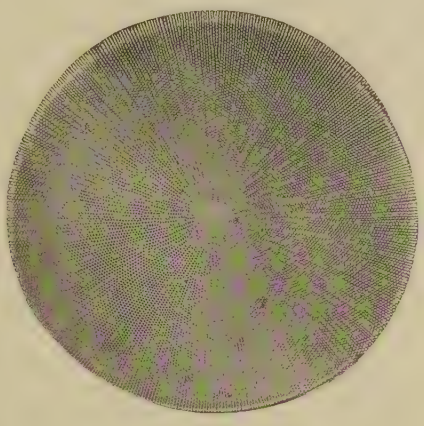
FIG. 1. *Bacteriastrum varians* Lauder.
2. *Bacteriastrum hyalinum* Lauder.
3. *Bacteriastrum varians* Lauder.
4. *Bacteriastrum minus* Karsten.
FIGS. 5, 6, and 7. *Bacteriastrum varians* Lauder.
FIG. 8. *Bacteriastrum comosum* Pavil. var. *hispida* (Castr.) Ikari.
9. *Biddulphia sinensis* Grev.
FIGS. 10 and 11. *Thalassiothrix nitzschioides* Grun.
FIG. 12. *Navicula kariana* Grun. var. *minor* Grun. forma *japonica* forma nov.
13. *Surirella gemma* Ehrenb. var. *ovata* var. nov.
14. *Corethron pelagicum* Brun.
15. *Navicula* (*Schizonema*) *mollis* W. Smith.
16. *Navicula* (*Cistula*) *lorenziana* Grun.

PLATE 9

FIGS. 1 and 2. *Thalassiothrix antarctica* Schimper forma *japonica* forma nov.
3, 4, and 5. *Synedra koreana* sp. nov.
FIG. 6. *Thalassiothrix nitzschioides* var. *javanica* Grun.
7. *Nitzchiella longissima* (Breb.) Ralfs forma *parva* V. Heurck.
8. *Thalassiothrix frauenfeldii* Grun.
9. *Asterionella japonica* Cleve.
10. *Planktoniella sol* (Wallich) Schütt.
FIGS. 11 and 12. *Navicula pellucida* Karsten.

PLATE 10

FIG. 1. *Nitzchiella longissima* (Breb.) Ralfs forma *typica* V. Heurck.
2. *Synedra auriculata* Karsten.
3. *Navicula* (*Schizonema*) *ramosissima* Ag. forma *amplia* Grun.
4. *Rhizosolenia robusta* Norman.
5. *Rhizosolenia setigera* Brightw.
FIGS. 6, 7, and 8. *Rhizosolenia hyalina* Ostenf.
9 and 10. *Rhizosolenia alata* Brightw.
11 and 12. *Rhizosolenia alata* forma *gracillima* (Cleve) Grun.
FIG. 13. *Grammatophora japonica* Grun.
14. *Pleurosigma wansbeckii* Donk.
15. *Pleurosigma longum* Cleve var. *inflata* Perag. forma *japonica* forma nov.



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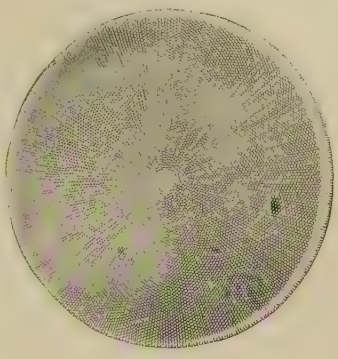

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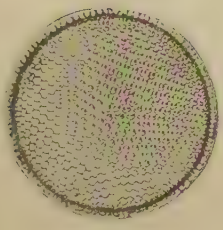

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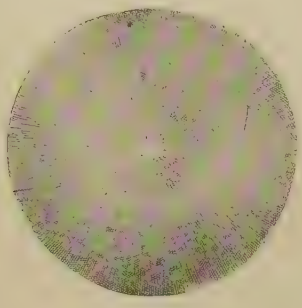

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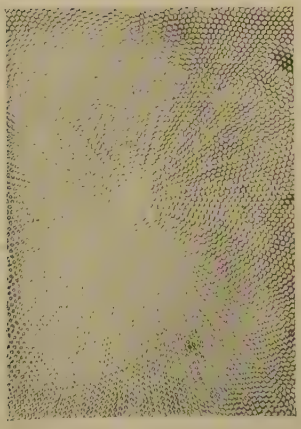

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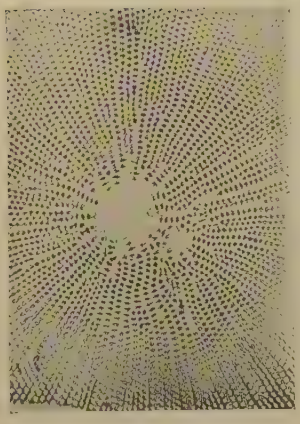

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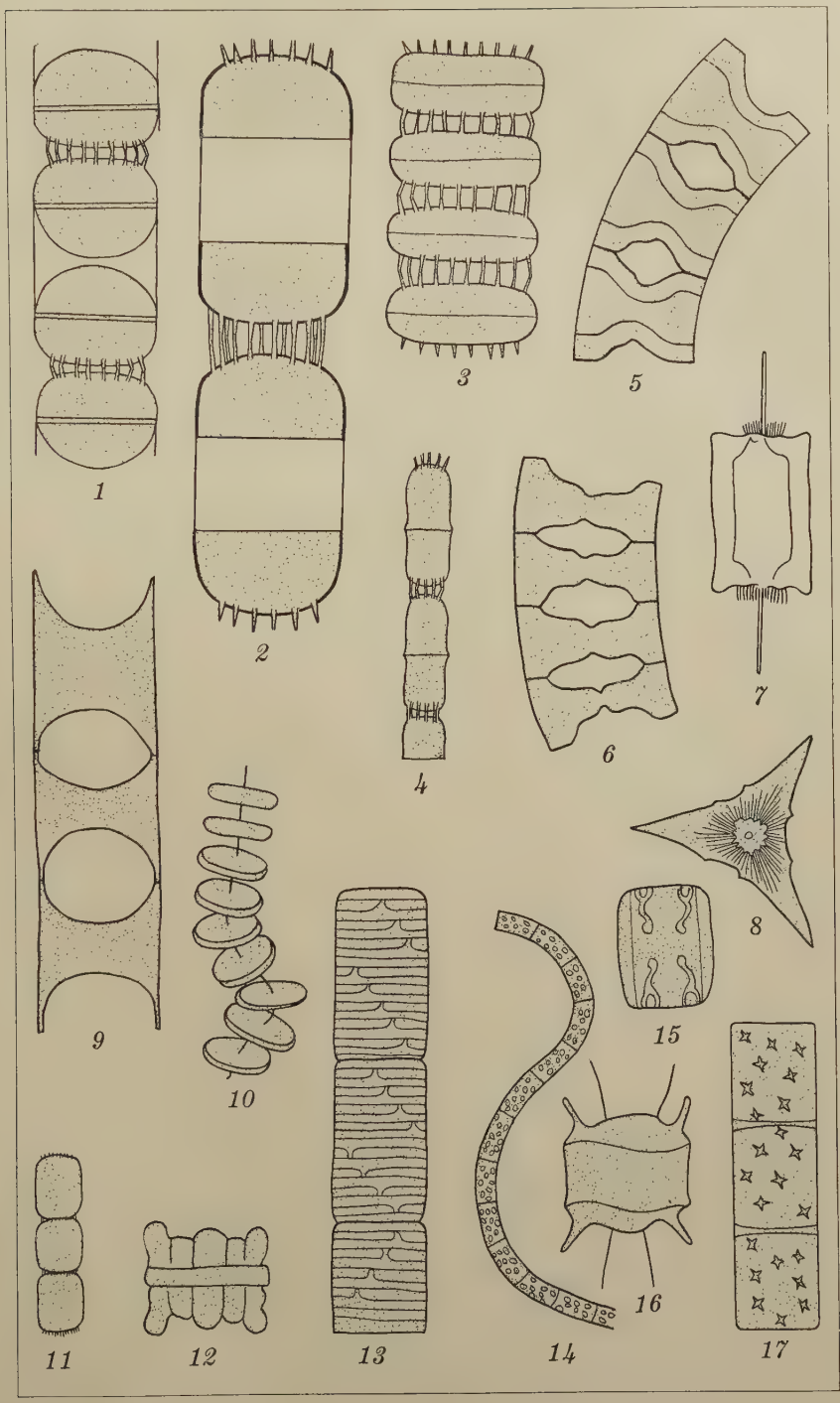

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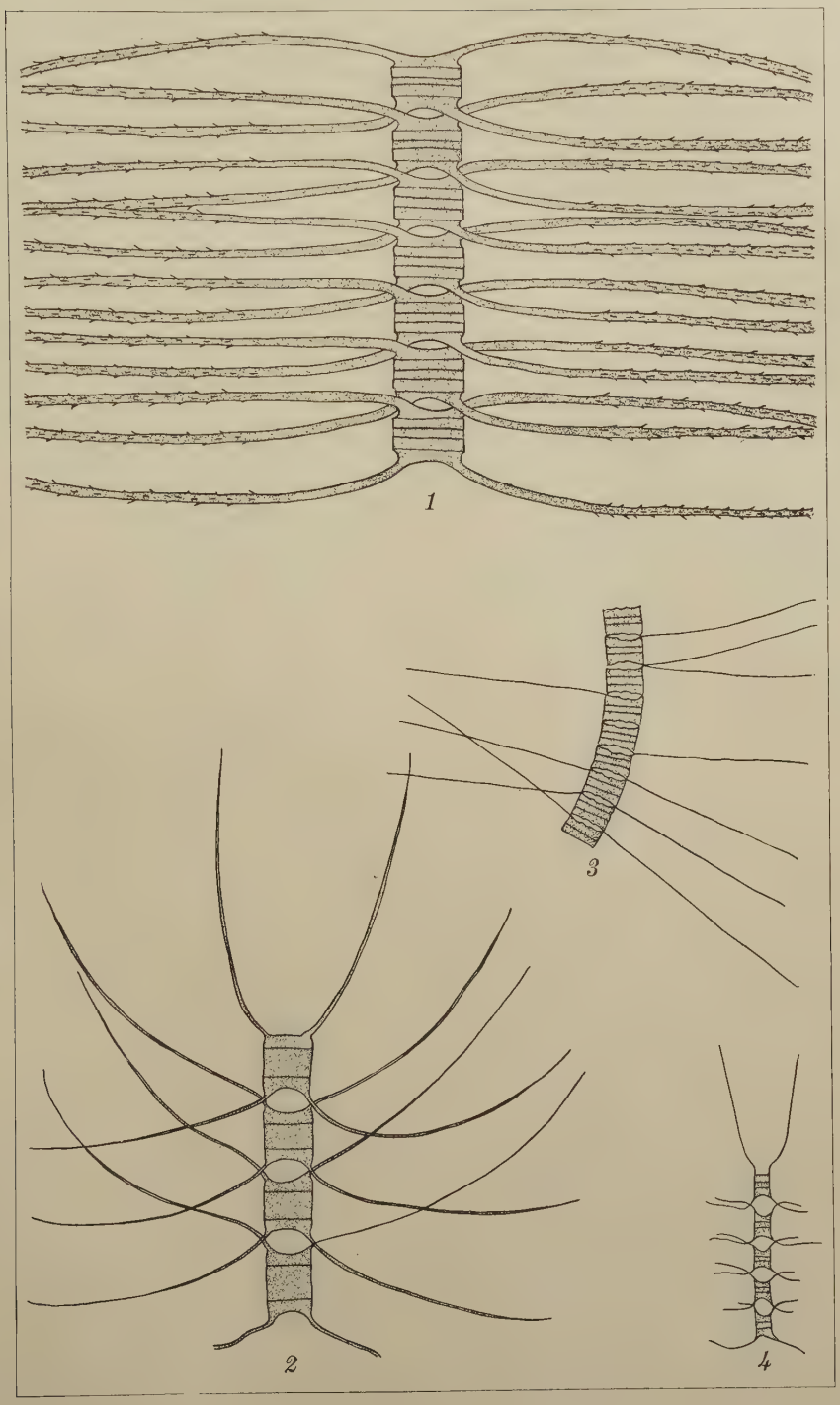

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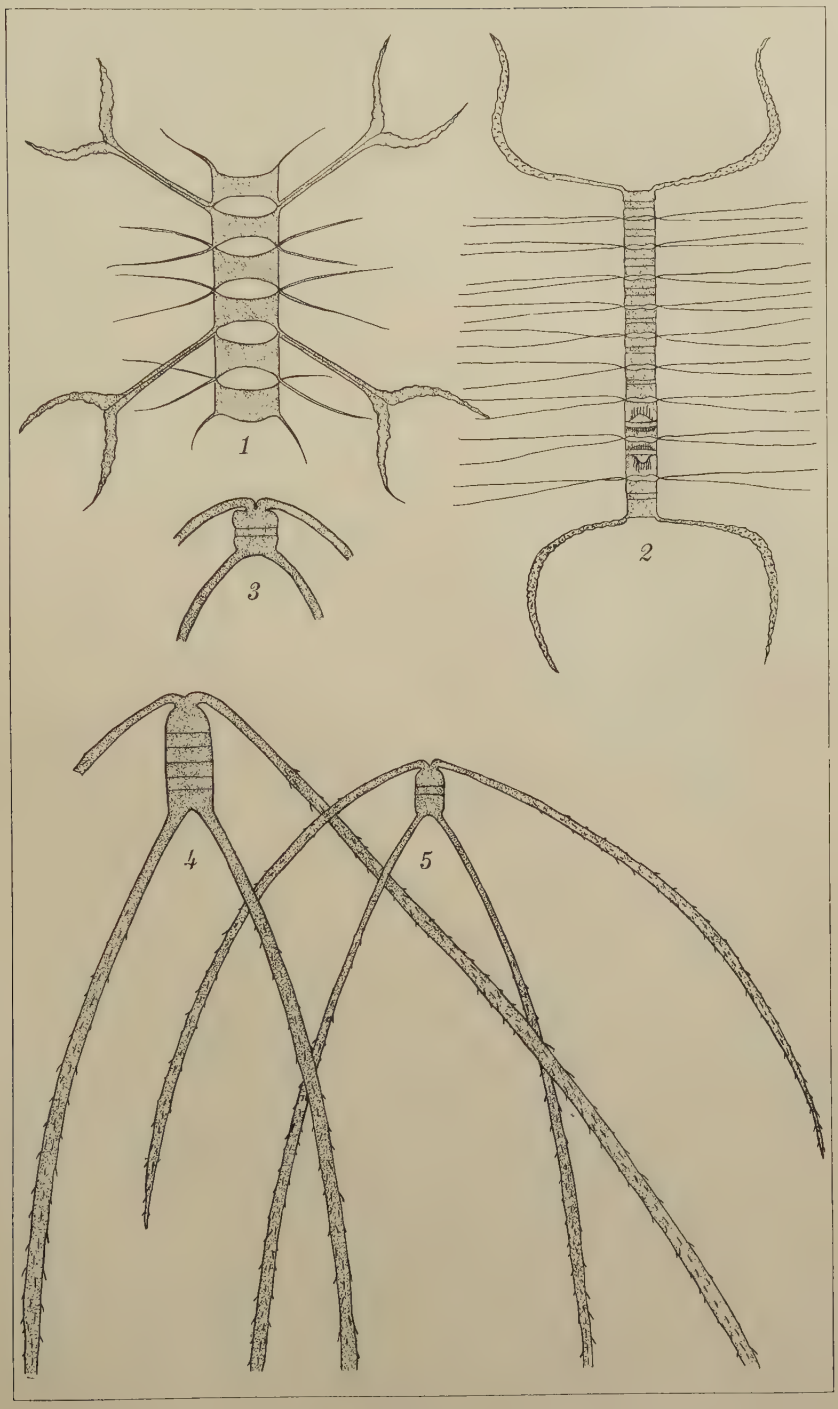

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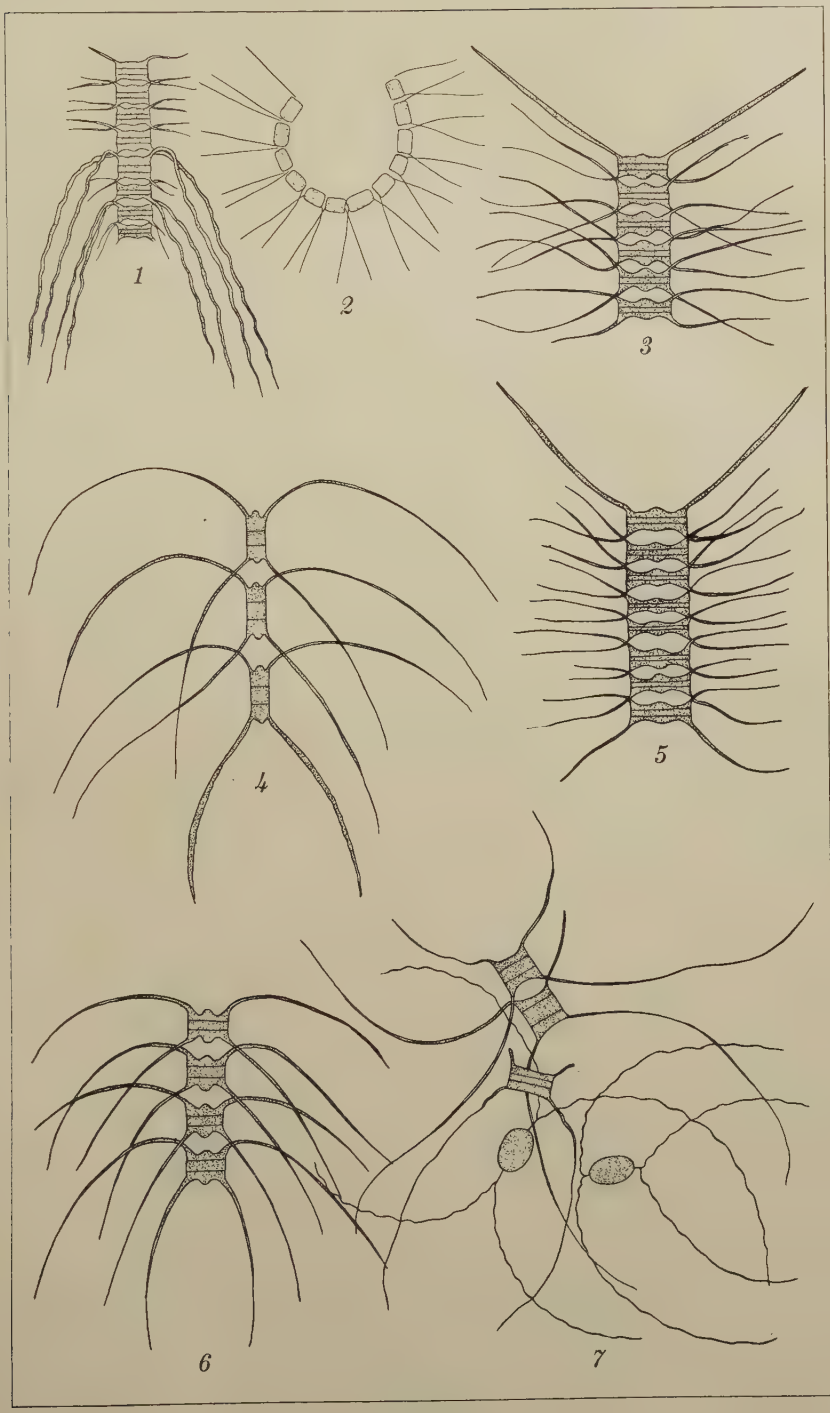

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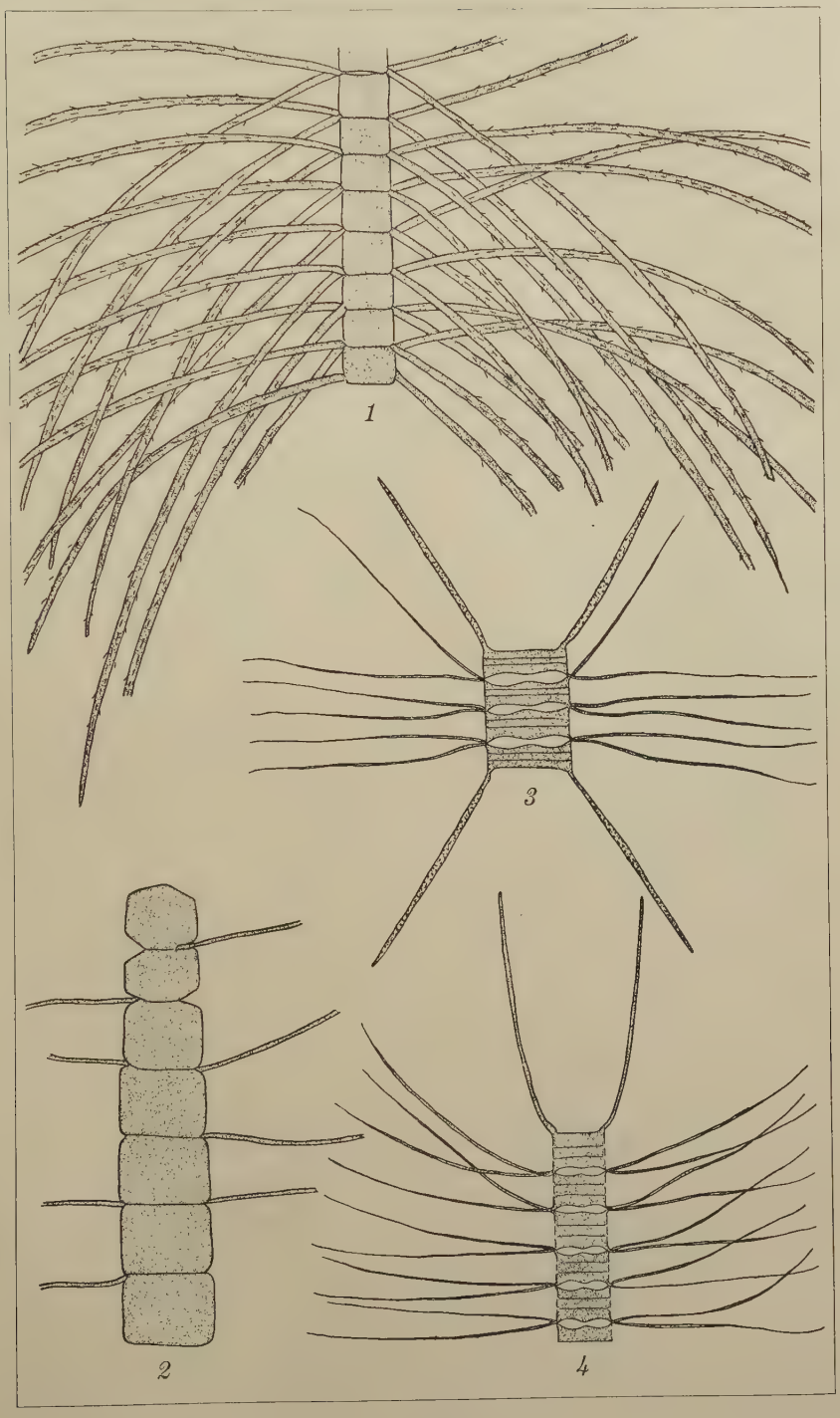

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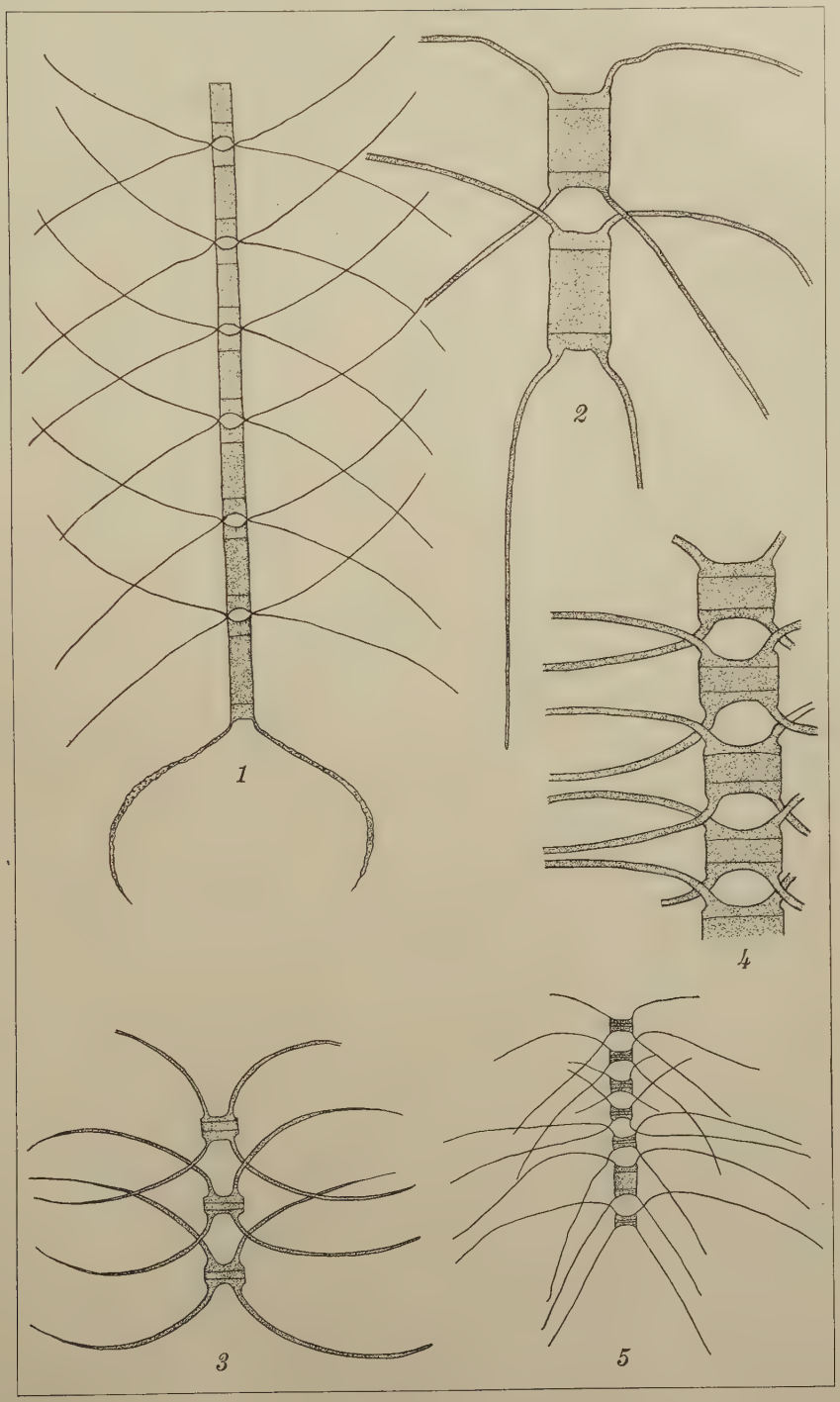

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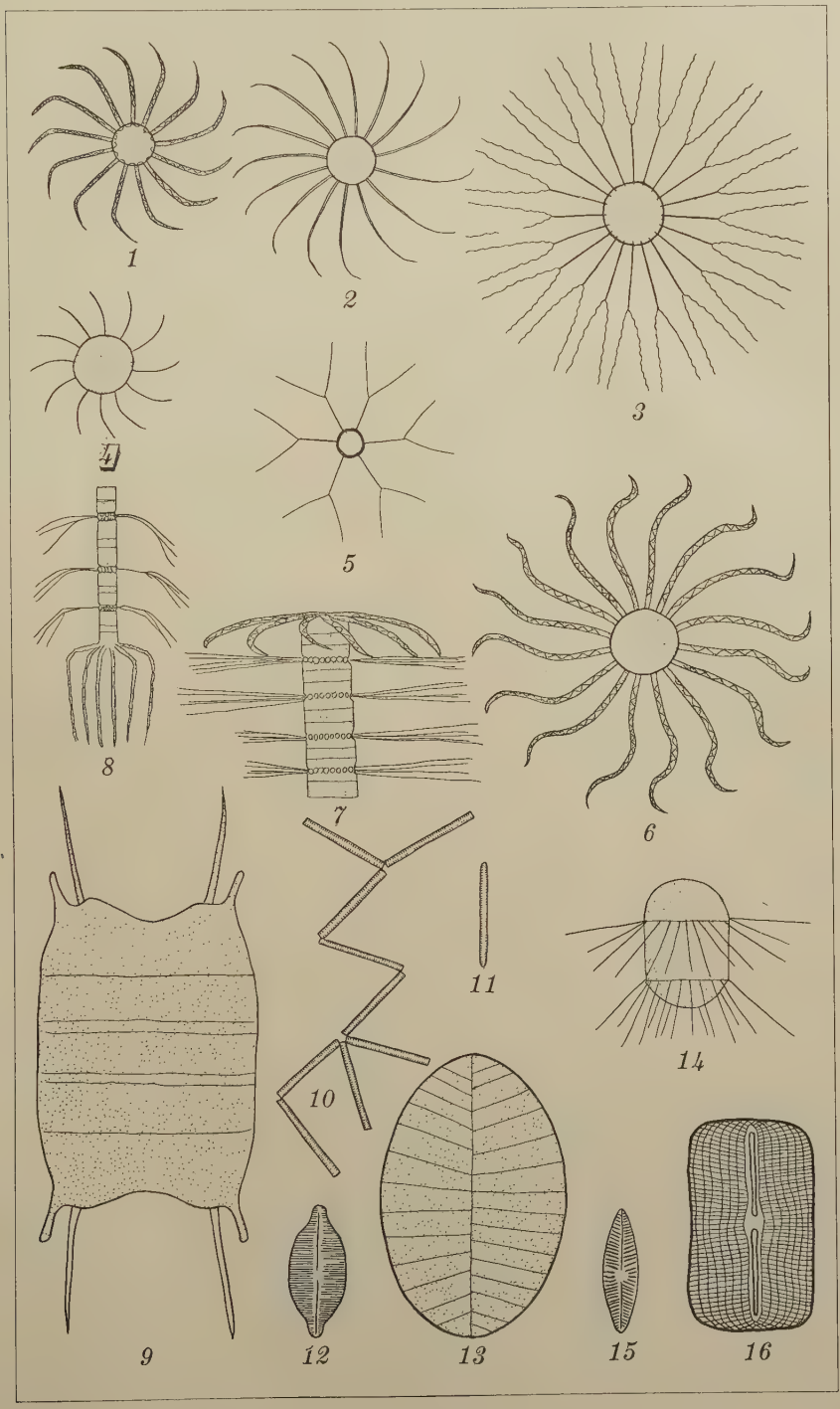

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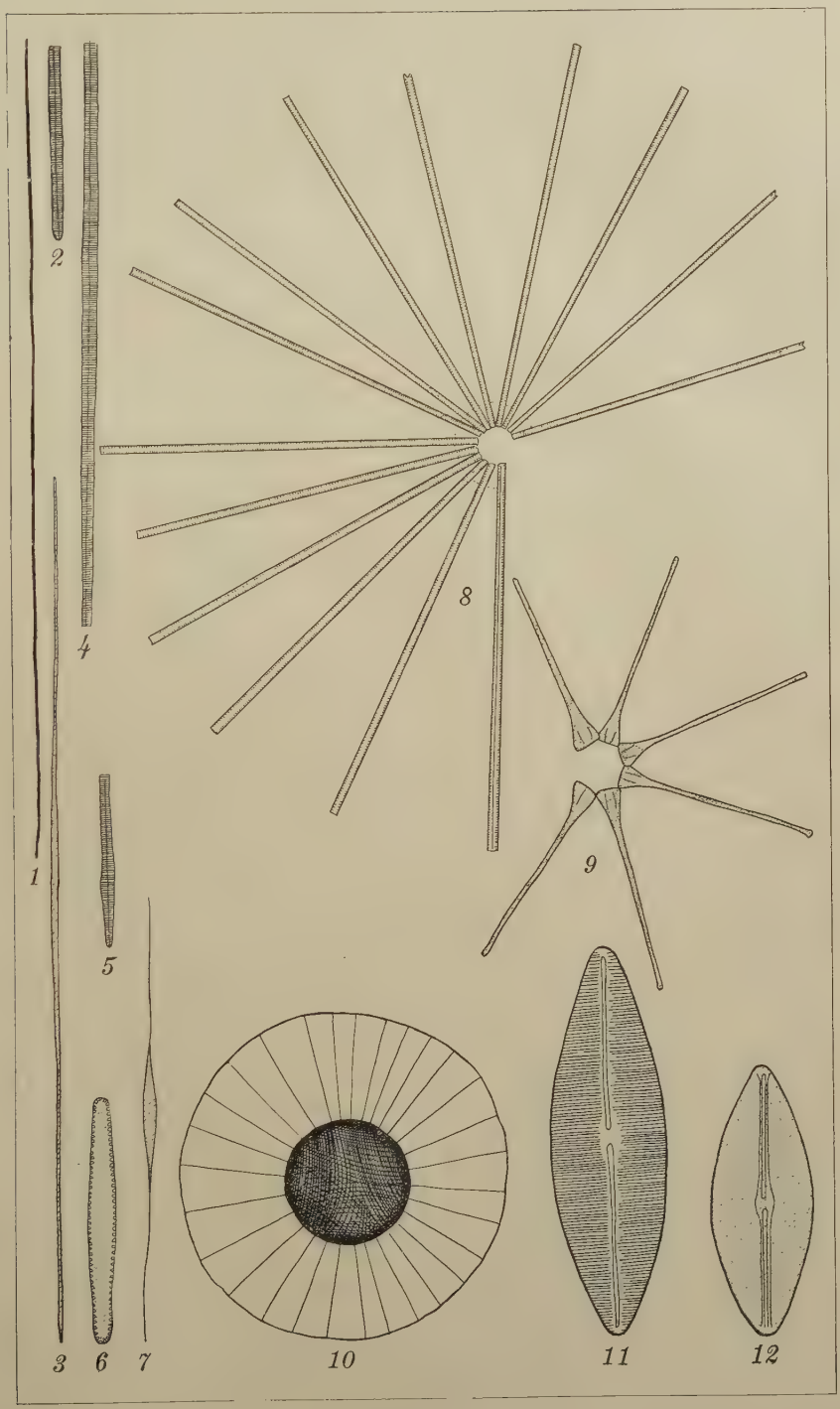

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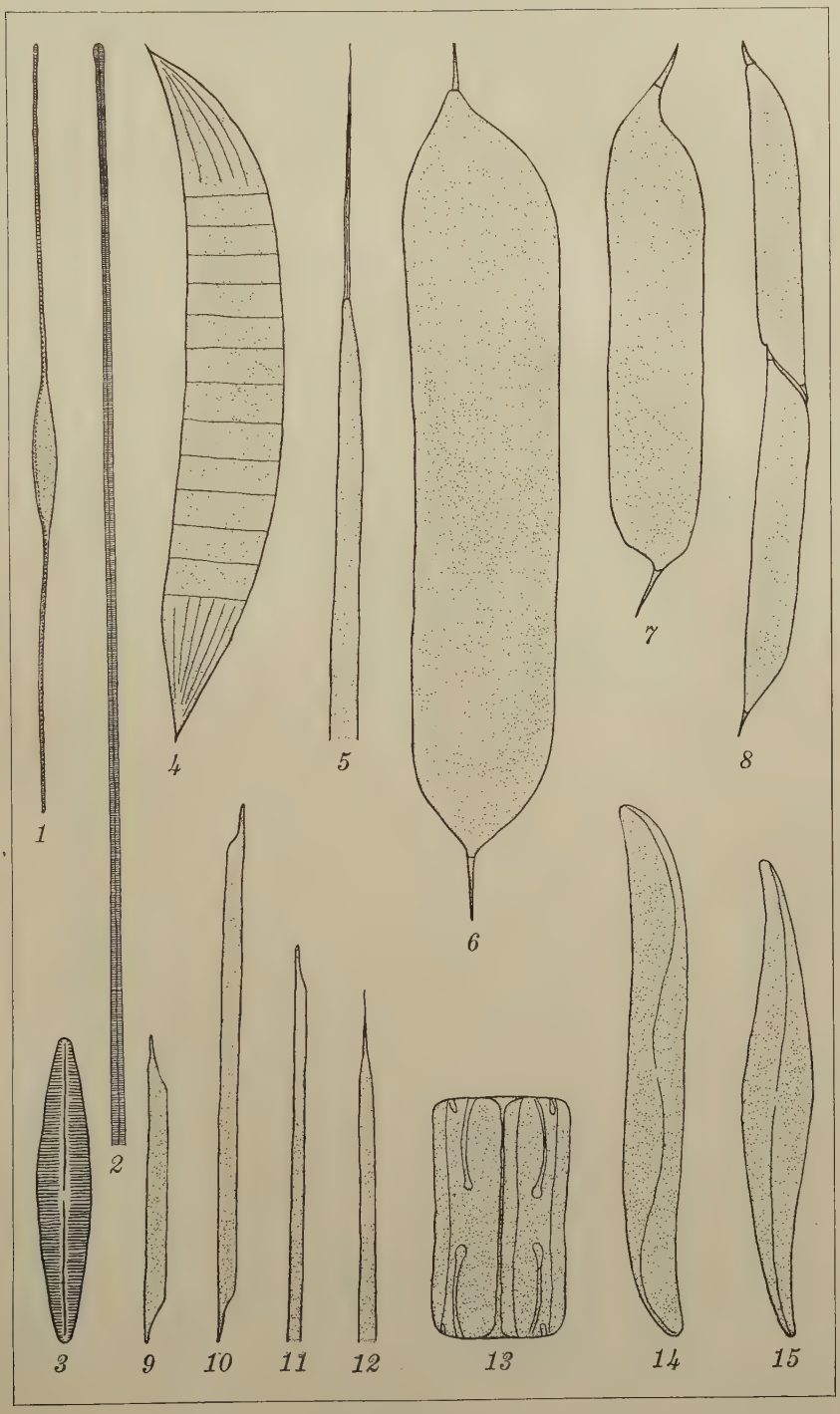


PLATE 10.

THE HISTAMINE TEST AS AN AID IN THE DIAGNOSIS OF EARLY LEPROSY

By Jose Rodriguez and Fidel C. Plantilla

Of the Philippine Health Service, Cebu, Cebu

It is generally agreed that one of the greatest needs in leprosy work to-day is a reliable serological test that can be depended upon to detect the disease in its earliest stages. Unfortunately, in spite of claims of some to the contrary, such a test does not yet exist. Until one has been elaborated and since in the "incipient stage" the presence of *Mycobacterium leprae* cannot usually be demonstrated on ordinary methods of making the bacteriological examination, we have to depend almost entirely on clinical methods such as the detection of the anæsthesia, palpation of thickened nerves and superficial glands, careful history-taking, and examination of the external lesions as to appearance, location, etc., in order to arrive at a diagnosis in this stage. Naturally the accuracy of the diagnosis must depend to a great extent on the experience of the physician making the diagnosis. The introduction, therefore, of any clinical test that will tend to minimize the influence of the personal equation should prove of value.

We believe that we have found such a test in the so-called "histamine test." When a dilute solution of histamine is pricked into the normal skin, a reaction takes place in about twenty seconds, starting with the appearance of a circular, sharply defined, local reddening surrounding the prick, and measuring when fully developed from 3 to 4 millimeters in diameter. This is followed in another fifteen to thirty seconds by a flush or "flare" that appears on the surrounding skin. It is of the utmost importance to distinguish this flare from the local red reaction. The flare is dark red or scarlet contrasting with the brighter shade of the latter; it has diffused and often crenated borders that may extend from 2 to 3 centimeters from the center of the reaction. Soon after the appearance of the flare, a discreet wheal forms at the site of the prick; this is generally at its maximum development in from three to five minutes, at

which time it measures from 3 to 4 millimeters in diameter and about 1 to 2 millimeters in height. The wheal usually occupies the area originally covered by the local red reaction, although in many cases the two do not coincide, the wheal being usually smaller than the localized red area.

The full reaction of the normal skin to histamine, consisting of the local redness or vasodilation, the flare, and the œdema or wheal has been called by Lewis [1] the "triple response."

Lewis has demonstrated that the triple response is a characteristic reaction of the normal skin following injury inflicted by such agents as heavy stroking, pricking, scratching, freezing, heating, electrical shocks, as well as by the introduction of irritant substances such as acids, alkalies, mustard oil, cantharidis, nettle sting, morphine, etc. Ultraviolet rays, ordinary sunlight, X-ray and radium emanations, bacterial poisons, certain chemicals such as dichloraethylsulphide, etc., give rise to more slowly developing reactions. He has also proven that the local redness and the wheal or œdema are due to direct action of the injury or irritant on the capillaries, while the flare is produced by the dilatation of the arched arterioles and is reflex in nature, being dependent upon the integrity of the cutaneous nerves. The arteriolar dilatation is mediated through a purely local nervous reflex and does not depend upon a spinal reflex arc.

This test has been tried by Lewis and his colleagues [2] on anæsthetic skin to which the sensory nerves have been cut surgically or interrupted by injection of anæsthetics. When the interruption produced surgically or by anæsthesia is recent, the reaction to the histamine test is complete in all its details, although the skin has already been rendered anæsthetic; but if sufficient time (six to fifteen days) is allowed for the nerve to degenerate after surgical section or if the skin is anæsthetized locally, the flare is lost. Under these circumstances, the local red reaction and the œdema appear as in the normal reaction of the skin.

Thus, the loss of the flare following a histamine test is a sign of degeneration of the sensory nerves supplying the skin tested, and possibly also of direct involvement of the nerve endings as in local anæsthesia.

[1] The Blood Vessels of the Human Skin and their Responses. Shaw & Sons, Ltd., London (1927) 47.

[2] Op. cit. 69–70.

Histamine, or β-iminazolylethylamine, is described by Lewis as "the amine produced when carbon dioxide is split from histidine, a substance occurring naturally in the body and a protein derivative." It was extracted by Barger and Dale [3] from the intestinal mucosa, and was later thoroughly studied by Dale and Laidlaw.[4] The histamine test as applied on the skin was first reported by Eppinger [5] and later elaborated by Sollman and Pilcher [6] and by Lewis and Grant.[7]

THE TEST

In most of our tests, we have used a 1 to 1,000 dilution of the phosphate in normal salt solution. With stronger solutions a larger flare is occasionally obtained, but the reactions are not as constant as with the 1 to 1,000 solution.

A small drop of the solution is carefully placed within the suspicious macule to be tested and another is dropped on normal skin at least 2.5 centimeters from the border of the lesion for control. With a sharp pin, a prick is made through the drop into the skin underneath, taking care to exert just sufficient pressure to drive the point through the epidermis without causing any bleeding. The histamine solution is wiped off immediately, and the pricks are closely observed under good natural light.

The test is said to be negative when the complete response is elicited and positive when the flare is absent.

There are some individuals on whom the normal reaction is diminished; in a few, the flare is so faint as to be practically absent. When the response is weak and the skin tested is on an extremity, the flare may be brought out to its maximum extent and intensity by previously congesting the extremity with the help of a broad rubber band or the pneumatic cuff of a blood-pressure apparatus.

Finally, it must be recognized that the reaction is harder to elicit on the dark skin of a Filipino than on white skin.

[3] Journ. of Physiol. 41 (1910–11) 499–503.

[4] Journ. of Physiol. 41 (1910–11) 318–344; 43 (1911–1912) 182–195.

[5] Wein. med. Wochenschr. 43 (1913) 1414.

[6] Journ. of Pharmacol. and Eper. Therap. 9 (1917) 309–340.

[7] Vascular Reactions of the Skin to Injury. Part II, Heart 11 (1924) 209–265.

RESULT OF THE HISTAMINE TEST IN LEPROSY

In the pale macule.—The flush is always absent in the depigmented macule of leprosy. When the histamine prick is made just outside the border, a flare develops on the normal skin but stops sharply at the border and does not extend into the macule. When the prick is made just inside the border, the flare is prevented from appearing even on the bordering normal skin.

A word of caution must be given at this point. The flare generally masks the local redness following the histamine test on the normal skin. When the flare is abolished as in a leprotic macule, the local redness becomes prominent and may be mistaken for the flare by the beginner. The area of local redness is sharply localized, circular in shape, bright red or pink in color, extending at the most 2 or 3 millimeters beyond the wheal, and tends to become cyanotic before fading. On the other hand, the flare is not definitely localized, the size is usually about 3 to 4 centimeters in diameter, irregular in shape, although it tends to be oblong with its long axis along the length of the member, and the color is dark red. On fading the flare becomes speckled, but the color remains the same from beginning to end.

The wheal in the macule is usually of the same size as that on the normal skin. Sometimes the œdema may be less; at other times the wheal develops faster in the macule, reaching its full development in two minutes, while the wheal on the control skin is at its height in three to five minutes. The ultimate size, however, is almost the same.

The test has been applied on the macules of *Tinea flava* and other types of pale-looking pityriases, on leucoderma, old scars, fading psoriasis lesions, etc., which may be mistaken for the pale macule of leprosy. In every case, the flare is present provided the individual is not unsusceptible to histamine, in which case, the flare is also diminished or absent on the normal skin.

In the reddish macule.—When the redness of the lesion is marked, only the wheal may be elicited; but when the color is not so striking, the local redness may be seen.

When hyperæsthesia is present, as is usually the case when the lesion is bacteriologically positive, the flare is not constant. In a few macules the flare is present; in the majority of the cases it is absent. If there is accompanying infiltration or œdema so marked that the skin looks tense, glistening, and bright red in color, the wheal is apt to be slight or absent.

The histamine test was tried in cases of dermatitis from various causes, active psoriasis lesions, tinea circinata and other ringworm infections, fresh scars, and other lesions that may simulate the red macule. When the inflammation in such lesions is active and there is considerable redness, the wheal is generally diminished or even absent while the flare is present, manifested by increased redness of the skin. It must be stated that when the redness of the original lesion is at all bright, it is next to impossible to distinguish the flare. When this is the case, the best way to perform the test is to prick the histamine solution just inside the border. In the nonleprotic lesion, the flare appears on the adjacent portion of the skin outside the border, whereas there is no such flare extending from the macule in early leprosy.

SUMMARY

1. The histamine test has been found to be a fairly reliable clinical test in differentiating the patches characteristic of the early stages of leprosy from nonleprotic macules.

2. This test is "positive" (the flare is absent) in the large majority of the bacteriologically negative leprotic macules tested.

3. The method of performing the test is described and its limitations mentioned.

THE FLY EUTRIXOPSIS JAVANA TOWNSEND (DIPTERA, TACHINIDÆ), A PARASITE OF THE BEETLE LEUCOPHOLIS IRRORATA IN OCCIDENTAL NEGROS, PHILIPPINE ISLANDS

By A. W. Lopez

Chief Entomologist, Research Bureau, Philippine Sugar Association

On April 10, 1930, four maggots of the tachinid fly *Eutrixopsis javana* Tns. were found in one specimen of the beetle *Leucopholis irrorata* Chevr.,[1] collected at Hacienda Candelaria, La Carlota, Occidental Negros Province. The maggots pupated April 11 and emerged April 20, a pupal period of nine days. The determination of the flies was made by Dr. J. M. Aldrich, of the United States National Museum, Washington, D. C.

The one specimen returned by Doctor Aldrich is in poor condition, and it is impossible to give a description of it. However, its length is 7 millimeters.

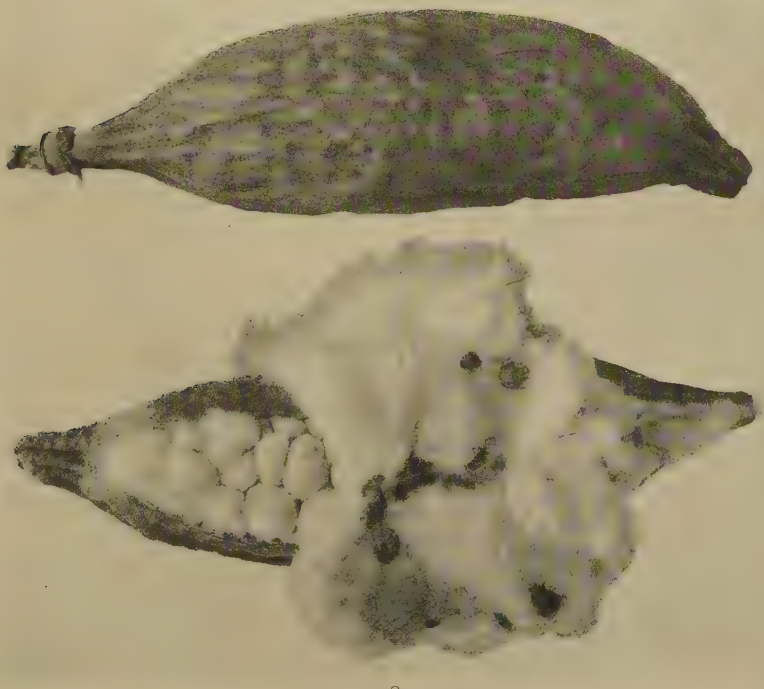
The publication Insecutor Inscitiae Menstruus[2] contains the following description of one male collected at Pelaboean, Ratoe, Java, by Bryant and Palmer.

> Length 5.5 mm. wholly brownish-fulvous, including antennae and palpi; tarsi darker, basal half or more of abdominal segments yellowish. Tegulae tawny-whitish. Wings clear.

The United States Department of Agriculture[3] reports that *E. javana* was unwittingly introduced into the United States from Sapporo, Japan, in 1922, with a shipment of material imported to obtain *Centeter cinerea,* a tachinid parasite of the Japanese beetle *Popillia japonica.* It is stated that the life cycle of *E. javana* apparently corresponds closely to that of *Centeter,* only one generation a year being produced.

[1] Coleoptera, Scarabæidæ, worst cane root-pest in the Philippine Islands.
[2] Nos. 10–12 6 (1918) 166.
[3] Bull. 1429: 19–20, with fig. of *E. javana.*

1



2

PLATE 1. PHILIPPINE KAPOK TREES AND SEED PODS.

COMPOSITION OF PHILIPPINE KAPOK-SEED OIL

By Aurelio O. Cruz and Augustus P. West

Of the Bureau of Science, Manila

ONE PLATE

Kapok-seed oil is obtained from the seeds of the silk-cotton tree (*Ceiba pentandra* Gaertner). Recently we determined the composition of Philippine kapok-seed oil and our results showed that this oil has a composition quite similar to that of American cottonseed oil.

The silk-cotton tree is commonly known as kapok. It is a tropical product and grows in tropical countries at such altitudes as are free from frosts. In general, kapok is especially suited to tropical lowlands. It is widely distributed in the Philippines. The kapok tree is slender and usually has a height of about 15 meters or less. The branches are borne in horizontal whorls that are very characteristic.

The kapok fruit is a capsule containing black seeds embedded in fine silky hairs, or floss. The kapok fibers, or floss, surrounding the seeds are soft, elastic, and immune to moths. Kapok floss has the property of being impermeable to moisture and is also extremely buoyant. For this reason kapok is used extensively for the manufacture of buoys, life belts, and life-saving jackets. The chief use of kapok is for stuffing cushions, pillows, mattresses, and similar articles. It is well adapted for this purpose on account of its lightness, its springy or resilient nature, and its nonhygroscopic and nonabsorbent characteristics. Kapok floss is superior to most other flosses in resiliency and consequently is more valuable for stuffing purposes. It has been used considerably for making "down" quilts, which are about as good as "eider down" quilts but much cheaper.

Kapok trees may be grown conveniently with other crops in mixed plantation cultivation. The cultivation of crops under kapok is quite practical because the few leaves and branches of the kapok tree produce very little shade.

Recently there have appeared several articles that give an excellent account of the cultivation of kapok, the harvesting, ginning, yields, insect pests, etc.[1]

Kapok trees begin to bear fruit in about four years, and when seven years old they may yield about 500 pods per tree. The yield naturally varies with the location and other factors. Under favorable conditions much larger yields are obtained. The number of pods required to produce a pound of clean floss is said to average about 100.

Several years ago Philippine kapok appeared to be a very prosperous and promising industry. Like other products, however, the value of kapok has decreased very considerably during the recent financial depression. In 1927 the amount of kapok exported from the Philippines[2] was 330,174 kilograms and the value was 325,770 pesos. During 1929 there were exported 330,312 kilograms but the value was only 64,338 pesos. Probably when trade conditions are again adjusted kapok will return to approximately normal values.

High-grade kapok-seed oil serves as an edible oil. The lower grades are suitable for soap making and other purposes for which low-grade cottonseed oil is employed. The oil cake left after expression of the oil may be used for live-stock food or fertilizer.

According to Lewkowitsch[3] kapok-seed oil is made in Holland from seeds imported from Java. The oil gives color reactions similar to those of cottonseed oil.

EXPERIMENTAL PROCEDURE

Philippine kapok pods, *Ceiba pentandra*, consist of about 51 per cent of husk and core, 32 per cent of seeds, and 17 per cent of floss. One pod weighs about 32 grams and gives an average of about 149 seeds, which weigh about 10 grams.

The Philippine kapok seeds used in this investigation were kindly given to us by Dr. Manuel Roxas, director, Bureau of Plant Industry. The seeds were ground in a mill after which they were cold pressed to obtain the kapok oil. The oil was purified by treating successively with 2 per cent Kieselguhr, Suchar, and talcum powder. This treatment removes vegetable

[1] Grist, D. H., Malayan Agr. Journ. 11 (1923) 3. Saleeby, M. M., The Kapok Industry, Bull. Philip. Bur. Agr. 26 (1922). Bull. Imp. Inst. 24 (1926) 18.

[2] Annual Report, Insular Collector of Customs, Manila (1928 and 1930).

[3] Chemical Technology and Analysis of Oils, Fats, and Waxes 2 (1922) 187.

fibers and colloidal matter and produces a brilliantly clear yellow oil with a slightly greenish tinge. The yield of oil calculated on a moisture-free basis was found to be about 25 per cent.

The constants of this sample of Philippine kapok-seed oil are given in Table 1.

TABLE 1.—*Physical and chemical constants of Philippine kapok-seed oil.*

Specific gravity at $\frac{30°}{4°}$ C.	0.9109
Refractive index at 30° C.	1.4678
Iodine number (Hanus)	95.6
Saponification value	192.1
Unsaponifiable matter (per cent)	0.78
Acid value	7.39
Saturated acids, determined (per cent)	21.73
Unsaturated acids plus unsaponifiable matter, determined (per cent)	72.62
Saturated acids, corrected (per cent)	18.64
Unsaturated acids, corrected (per cent)	75.71
Iodine number of unsaturated acids plus unsaponifiable matter	123.4
Iodine number of unsaponifiable matter	82.4
Iodine number of unsaturated acids (calculated)	123.9

The saturated and unsaturated acids that occur as glycerides in Philippine kapok oil were separated by the lead-salt-ether method [4] in accordance with the suggestions of Baughman and Jamieson.[5] The results are recorded in Table 2.

TABLE 2.—*Separation of saturated acids from the unsaturated acids in Philippine kapok-seed oil by the lead-salt-ether method.*

Experiment No.	Oil used.	Unsaturated acids.	Saturated acids.	Unsaturated [a] acids (determined).	Saturated acids (determined).	Unsaturated acids (corrected).	Saturated acids (corrected).
	g.	*g.*	*g.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	9.7005	7.0033	2.1209	72.20	[b] 21.86	75.25	18.81
2	11.5115	8.4079	2.4870	73.04	[c] 21.60	76.17	18.47
Mean				72.62	21.73	75.71	18.64

[a] Iodine number (Hanus) of unsaturated acids plus unsaponifiable matter, 123.4.
[b] Iodine number (Hanus), 17.2.
[c] Iodine number (Hanus), 17.9.

The unsaturated acids separated from kapok oil by the lead-salt-ether method were treated with bromine and converted into their bromo-derivatives. No ether-insoluble hexabromide was obtained, thus showing the absence of linolenic acid. The com-

[4] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 556.

[5] Cotton Oil Press 6 (1922) 41. Journ. Am. Chem. Soc. 42 (1920) 2398.

position of the mixed unsaturated acids, which occur as glycerides in kapok oil, was calculated from the iodine number of the unsaturated acids. The results are recorded in Table 3. There are also included the calculated percentages of glycerides corresponding to these individual unsaturated acids.

TABLE 3.—*Percentage composition of the unsaturated acids of kapok-seed oil and the glycerides corresponding to these acids.*

Acid.	Mixture of unsaturated acids.[a]	Original oil.	Glycerides in original oil.
	Per cent.	*Per cent.*	*Per cent.*
Linolic	37.02	28.03	29.29
Oleic	62.98	47.68	49.83
Total	100.00	75.71	79.12

[a] Calculated iodine number of the pure unsaturated acids was 123.9.

Saturated acids.—The saturated acids were separated from Philippine kapok oil by the lead-salt-ether method and esterified with methyl alcohol. The mixed acids were dissolved in methyl alcohol and saturated with dry hydrogen chloride gas. The mixture was then heated on a water bath (reflux) for fifteen hours, after which it was treated with water and the ester layer separated. The esters were dissolved in ether and the ethereal solution washed with sodium carbonate solution and afterwards with water. The ethereal solution was then dehydrated with anhydrous sodium sulphate, filtered, and the ether removed by distilling. The impure esters (83.97 grams), which were yellow, were distilled under diminished pressure. A preliminary distillation at about 3 millimeters pressure was made. The esters (83.93 grams) were then redistilled at 3 millimeters pressure. Data on the distillation of the esters are given in Tables 4 and 5.

TABLE 4.—*First distillation of the methyl esters of the saturated acids; pressure, 3 millimeters; 83.97 grams of esters distilled.*

Fraction.	Temperature.	Pressure.	Weight.
	°*C.*	*mm.*	*g.*
A	163–167	3	19.43
B	167–170	3	19.98
C	170–174	3	17.07
D	174–196	3	22.34
Residue	----------	----------	5.10
Total	----------	----------	83.92

TABLE 5.—*Second distillation of the methyl esters of the saturated acids; pressure, 3 millimeters; 83.92 grams of esters redistilled.*

Fraction.		Temperature.	Pressure.	Weight.
From first distillation.	Second distillation.			
		°C.	*mm.*	*g.*
A	1	163–167	3	21.19
B and C	2	167–169	3	33.04
D	3	169–175	3	13.00
Residue	4	175–192	3	8.99
	5	192–222	3	5.94
	Residue			1.67
Total				83.83

In Table 6, are given the analyses of fractions obtained in the second distillation of methyl esters. From the data (Table 6), there were calculated the amounts of the individual acids corresponding to the methyl esters contained in the various fractions. The results are recorded in Table 7 and were calculated in accordance with the methods outlined by Baughman and Jamieson in their investigations of Hubbard squash-seed oil [6] and also American cottonseed oil.[7]

In Table 8 is given the composition of the mixed saturated acids and the glycerides in the original sample of kapok-seed oil corresponding to these acids.

TABLE 6.—*Analyses of fractions obtained in the second distillation of the mixed methyl esters.*

Fraction.	Iodine number.[a]	Saponification value.[b]	Mean molecular weight of mixed esters.	Composition of mixed esters.		Mean molecular weight of saturated esters.
				Saturated	Unsaturated.	
				Per cent.	*Per cent.*	
1	5.93	208.5	269.1	94.95	5.05	267.8
2	9.73	204.9	273.8	91.72	8.28	271.9
3	21.75	202.7	276.8	81.49	18.51	272.9
4	37.39	194.2	288.9	68.18	31.82	285.9
5	39.99	184.8	303.6	65.97	34.03	308.2

[a] Calculated iodine number of unsaturated methyl esters was 117.5.
[b] Calculated saponification value of unsaturated methyl esters was 190.0.

[6] Journ. Am. Chem. Soc. 42 (1920) 156.
[7] Journ. Am. Chem. Soc. 42 (1920) 1197.

TABLE 7.—*Saturated acids corresponding to methyl esters in each fraction.*

Fraction.	Acid.							
	Myristic.		Palmitic.		Stearic.		Arachidic.	
	Per cent.	*g.*	*Per cent.*	*g.*	*Per cent.*	*g.*	*Per cent.*	*g.*
1	7.96	1.69	82.02	17.38				
2			82.00	27.09	4.99	1.65		
3			70.09	9.11	7.21	0.94		
4			28.64	2.58	36.20	3.25		
5					40.87	2.43	22.10	1.31
Residue [a]								1.59
Total		1.69		56.16		8.27		2.90

[a] Residue assumed to be methyl arachidate.

TABLE 8.—*Saturated acids.*

Acid.	Mixture of saturated acids.			Glycerides in original oil.
	Weight.	Composition.	Proportion in original oil.	
	g.	*Per cent.*	*Per cent.*	*Per cent.*
Myristic	1.69	2.45	0.46	0.49
Palmitic	56.16	81.37	15.17	15.91
Stearic	8.27	11.98	2.23	2.33
Arachidic	2.90	4.20	0.78	0.81
Total	69.02	100.00	18.64	19.54

The composition of Philippine kapok-seed oil is given in Table 9. There is also included for comparison the analysis of American cottonseed oid.

TABLE 9.—*Composition of Philippine kapok-seed oil compared with American cottonseed oil.*

Constituent.	Philippine kapok-seed oil.	American cottonseed oil.[a]
Glycerides of:		
Unsaturated acids—	*Per cent.*	*Per cent.*
Oleic	49.8	35.2
Linolic	29.3	41.7
Saturated acids—		
Myristic	0.5	0.3
Palmitic	15.9	20.0
Stearic	2.3	2.0
Arachidic	0.8	0.6
Unsaponifiable matter	0.8	
Total	99.4	99.8

[a] Composition determined by J. S. Jamieson and W. F. Baughman, Journ. Am. Chem. Soc. 42 (1920) 1197.

The determined iodine number of Philippine kapok-seed oil was found to be 95.6 and the determined saponification value 192.1. The calculated iodine number is 93.8 and the saponification value 191.3. The iodine and saponification values calculated from the composition of the oil agree very closely with the determined values.

SUMMARY

Kapok floss is an excellent material for stuffing cushions, pillows, mattresses, buoys, life-saving jackets, and similar articles. It is well adapted for this purpose on account of its lightness, its springy or resilient nature, and its nonhygroscopic and nonabsorbent characters.

Kapok can be grown in the Philippines conveniently with other crops in mixed plantation cultivation.

The composition of Philippine kapok-seed oil has been determined, and the results (Table 9) indicate that the Philippine oil has a composition very similar to that of American cottonseed oil.

The percentage of linolic and palmitic glycerides is slightly higher in the cottonseed oil than in the kapok oil. The kapok-seed oil has a higher percentage of oleic glyceride than the cottonseed oil, while the percentage of the other glycerides is about the same.

Since Philippine kapok floss is superior to most other flosses and kapok seeds yield an oil of high quality and of about the same composition as American cottonseed oil, it would seem that there are promising prospects for the development of kapok cultivation in the Philippines under normal trade conditions.

ILLUSTRATION

PLATE 1. Philippine kapok trees and seed pods. 139

THE SKELETON OF THE TIMARAU

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THREE PLATES AND FOUR TEXT FIGURES

This paper records some observations on the characteristic features of the skeleton of the full-grown timarau (also spelled timerau and tamarao), a wild species of the family Bovidæ, confined to Mindoro Island, and the largest indigenous mammal of the Philippines. A careful search of the literature on hand has shown nothing about the internal features of this animal. With the hope of partially filling this gap in our knowledge the present study was undertaken.

In the following account an attempt will be made to point out where the skeleton of the animal in question differs from those of the carabao and the cow, making the descriptions of the individual bones comparative, where comparison is possible.

Concerning the habitat, size, and external features of this animal, Steere (1888) states in part:

> I have been in the interior of the little-known island of Mindoro, and have had the satisfaction of procuring specimens of a strange animal there, which, though generally talked of throughout the Philippines, is little known to scientific men. This is the "Tamaron". From the native reports I could make out nothing, but that it was a large fierce beast with sharp horns, which attacked all who came near it . . .
>
> In Mindoro I procured three full-grown individuals (two males and one female) of the "Tamaron," and have preserved the skins and skeletons . . . General color of the skin and hair black, hair short and rather fine. A grayish-white stripe running from near the inner corner of the eye towards the base of the horn (this stripe three inches long by one inch wide), a grayish-white spot above each hoof on all feet, a grayish-white patch on inner side of lower foreleg; skin and hair of groin white; bare skin of nose and lips black; horns and hoofs black; tips of horns pointed and polished; horns triangular, with a tendency in the bulls towards thickening and flattening at the base; lower part of the horns with deep irregular pits; several of the last vertebrae of the tail aborted.
>
> Size of No. 1: An old bull: length from point of nose to tip of tail eight feet one inch; length of tail one foot five inches; length of tassel of hairs at end of tail two and a half inches; height at shoulder three feet six

inches; from breast-bone to sole of fore foot one foot eight inches; length of horn one foot two inches; circumference of horns at base thirteen inches; horns distance apart at base one and a half inches, at points ten inches; length of head, before skinning, one foot four inches.

Montellano (1929) describes the timarau as follows:

The tamaraw is much like the domesticated carabao, except in size, shape, and size of horns, and conformation of the body. The tamaraw is smaller. The horns are rather short and straight, point vertically upward, and gradually taper to a sharp point admirably adapted for fighting. The body is lighter and shallower, and is better adapted to rapid movement than is that of the domesticated carabao.

These animals, however, are not the ancestors of the wild carabaos found elsewhere in the Philippines, and in Borneo and other neighboring islands, and in Southern Asia.

According to Sclater (1888), Steere proposed to call this species *Anoa mindorensis*, because of its very close resemblance to the *Anoa* of Celebes; but *Bubalus mindorensis*, as proposed by Heude (1888), seems to have been finally accepted. Meyer (1878) is of the opinion that the timarau is entirely different from the *Anoa* of Celebes. Bartlett as well as Gray (1878) believes that it is but a "small variety of the common Manila or water Buffalo." As reported by "Péres de la Campagnie de Jesus (1888)," it is not at all a type of ordinary buffalo. Their report asserts that a buffalo that has escaped from its owner and has become wild for a long time will never produce a timarau. This agrees with the observation of Steere that the timarau is distinctly different from the so-called "carabao cemaron," a wild carabao found in the Philippines, especially in Luzon.

Mention of the timarau as a source of food supply has been made by Miller (1912) in his study of the Mangyans of Mindoro.

In the preparation of this paper the previous work of the writer (1926) on the skeleton of the carabao (*Bubalus bubalis*), the Filipino beast of burden, was freely consulted.

MATERIAL

The data presented here were obtained from a thorough study of the mounted skeleton of an adult timarau in the anatomical museum of the College of Veterinary Science, University of the Philippines, and of another in the museum of the University of Santo Tomas, Manila. So far as the writer is aware these are the only mounted skeletons of this animal in the Philippines. The skeleton at Santo Tomas University is

incomplete, the mandible as well as some of the small bones of the limbs being lacking, and no data could be obtained as to the history of the animal from which it was prepared. The specimen at the College of Veterinary Science is a complete articulated skeleton of an adult timarau which, so far as the writer could recall, was presented to the College in 1916 by an American gentleman with the request that it be sacrificed.

OSTEOLOGY

The following are the bones of the various regions of the skeleton of the timarau:

THE AXIAL SKELETON

A. The Skull.
  1. Bones of the cranium.
    a. Single bones.
      1. Occipital.
      2. Sphenoid.
      3. Ethmoid.
    b. Paired bones.
      1. Interparietal.
      2. Parietal.
      3. Frontal.
      4. Temporal.
  2. Bones of the face.
    a. Single bones.
      1. Vomer.
      2. Hyoid.
      3. Mandible.
    b. Paired bones.
      1. Maxilla.
      2. Premaxilla.
      3. Nasal.
      4. Malar.
      5. Lacrimal.
      6. Pterygoid.
      7. Palatine.
      8. Dorsal turbinate.
      9. Ventral turbinate.

B. The Trunk.
  1. The vertebral column.
    a. Cervical vertebræ, 7.
    b. Thoracic vertebræ, 13.
    c. Lumbar vertebræ, 6.
    d. Sacral vertebræ, 5.
    e. Coccygeal vertebræ, 15.
  2. The thorax.
    a. Ribs (both sides), 26.
    b. Sternum (7 sternebræ), 1.

THE APPENDICULAR SKELETON

A. Bones of the Thoracic, or Pectoral, Limb.
  a. Shoulder.
    1. Scapula (both sides), 2.
  b. Arm.
    1. Humerus (both sides), 2.
  c. Forearm.
    1. Radius (both sides), 2.
    2. Ulna (both sides), 2.
  d. Manus.
    1. Carpus (both sides), 12.
    2. Metacarpus (both sides), 2.
    3. Digits.
      a. Phalanges (both sides), 20.
      b. Sesamoids (both sides), 12.

B. Bones of the Pelvic Limb.
  a. Pelvic girdle.
    1. Os coxæ (both sides), 2.
  b. Thigh.
    1. Femur (both sides), 2.
  c. Leg.
    1. Tibia (both sides), 2.
    2. Fibula (both sides), 2.
    3. Patella (both sides), 2.
  d. Pes, or hind foot.
    1. Tarsus (both sides), 10.
    2. Metatarsus (both sides), 4.
    3. Digits.
      a. Phalanges (both sides), 20.
      b. Sesamoids (both sides), 12.

In the preceding enumeration mandible, hyoid, and sternum are regarded as single bones, and the os coxæ is not divided into its original parts—ilium, ischium, and pubis. The visceral or splanchnic bones as well as the auditory ossicles are not included.

For the purpose of giving an idea of the difference in size between the skeleton of the timarau and that of the carabao, measurements of the various parts of the mounted skeleton of the timarau of the College of Veterinary Science and that of a medium-sized adult carabao were taken. The length or height of the flat and long bones of both the thoracic and pelvic limbs were likewise determined. The results are given in Tables 1 and 2.

TABLE 1.—*Showing the measurements of the various segments or regions of the articulated skeleton of a timarau and of a medium-sized carabao.*

[Measurements in centimeters.]

Region.	Length.		Height.		Width.		Depth.		Circumference.		Excess in favor of carabao.
	Carabao.	Timarau.	Carabao.	Timarau.	Carabao.	Timarau.	Carabao.	Timarau.	Carabao.	Timarau.	
Vertebral column	175.0	123.0									52.0
Tail	68.0	35.0									33.0
Skull	50.5	35.5									15.0
					20.0	14.5					5.5
							30	21.5			8.5
Horn core	34.0	15.5									18.5
									28	15	13.0
Between bases of horn cores					17.5	7.5					10.0
Between points of horn cores					73.0	21.5					51.5
Thoracic limb			115	82							33.0
Pelvic limb			118	85							33.0

TABLE 2.—*Showing the height or length of the individual long and flat bones of the appendicular skeleton of a timarau and of a medium-sized carabao.*

[Measurements in centimeters.]

Thoracic limb.				Pelvic limb.			
Bone.	Carabao.	Timarau.	Excess in favor of carabao.	Bone.	Carabao.	Timarau.	Excess in favor of carabao.
Scapula	34.0	22.5	11.5	Os coxæ	48.0	32.0	16.0
Humerus	27.5	20.0	7.5	Femur	38.0	28.0	10.0
Radius	29.5	21.0	8.5	Tibia	32.0	24.5	7.5
Ulna	37.0	29.5	7.5	Large metatarsal	20.0	14.5	5.5
Large metacarpal	18.0	12.0	6.0	First phalanx	6.5	5.0	1.0
First phalanx	5.5	4.5	1.0	Second phalanx	4.5	3.5	1.0
Second phalanx	3.5	3.0	0.5	Third phalanx	7.5	4.5	3.0
Third phalanx	6.5	4.0	2.5				

The distance between the level of the foramen magnum and that of the posterior aperture of the sacral canal constitutes the length of the vertebral column indicated in the table. The length of the skull here was measured from the nuchal crest to the central incisor teeth; the width refers to the broadest part of its frontal surface, measuring along an imaginary line

connecting the two supraorbital foramina. The depth refers to the broadest part of its lateral surface including the mandible, and was determined by measuring the distance between the angle of the mandible and the level of the most prominent part of the frontal region just in front of the base of the horn core. The height of the anterior limb constitutes the distance, in a straight line, between the highest point of the anterior or cervical angle of the scapula and the ground plane, whereas that of the posterior limb, is the distance between the highest point of the tuber coxæ and the ground plane.

THE SKULL

BONES OF THE CRANIUM

Occipital.—The occipital bone is very much less extensive than that of the carabao or ox. The external surface of the squamous and lateral parts, when taken as a whole, instead of being flattened as in the carabao, is convex transversely. The nuchal crest is markedly better developed, but the external occipital protuberance is only represented by a rather faint elevation, which is flanked on either side by a depression. The median occipital crest is only represented here by a low ridge and does not reach the upper border of the foramen magnum, fading out halfway between its margin and the external occipital protuberance. It terminates into a rather deep depression bounded on either side by a rounded muscular eminence formed by the fusion of the squamous and lateral parts. The foramen magnum is comparatively smaller, and its roof is perforated by three small foramina located a short distance from its margin. The paramastoid processes are short, being about one-half the length of those of the carabao. The basilar part is likewise relatively shorter and does not form with the body of the sphenoid prominent ventral tubercles. The edge dividing the articular surface of the condyle into an upper and a lower facet is better defined. Except in size the hypoglossal and mastoid foramina present no striking features.

Sphenoid.—The body of the sphenoid is narrow and short and the temporal and orbital wings are less extensive. As in the carabao there is a deep pituitary fossa and a very well-developed dorsum sellae. The foramen orbito-rotundum as well as the foramen ovale presents no special features other than its small size. The pterygoid crest is not well developed.

Ethmoid.—The ethmoid and its cells are well developed, differing only from those of the carabao in size. No attempt was

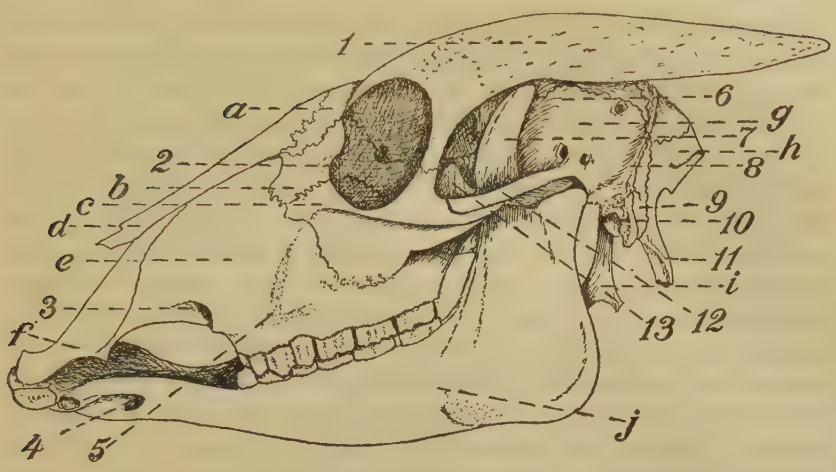

FIG. 1. Lateral view of the skull of the timarau. *a*, Part of the frontal bone; *b*, lacrimal; *c*, malar; *d*, nasal; *e*, maxilla; *f*, premaxilla; *g*, temporal; *h*, occipital; *i*, hyoid; *j*, mandible; *1*, horn core; *2*, lacrimal fossa; *3*, infraorbital foramen; *4*, mental foramen; *5*, maxillary tuberosity; *6*, temporal fossa; *7*, coronoid process of the mandible; *8*, temporal crest; *9*, mastoid process; *10*, external acoustic meatus; *11*, paramastoid process; *12*, zygomatic arch; *13*, lacrimal bulla.

made to discover an air sinus in its perpendicular plate, which is sometimes observed in carabao.

Interparietal.—The interparietal is completely fused behind with the supraoccipital. Its external surface is smooth and flat instead of convex as in the carabao; the cranial aspect is like that of the same bone in the carabao or cow, carrying no distinct tentorium osseum.

Parietal.—The external parietal crest is curved and better defined than that of the carabao. This crest distinctly divides the parietal bone into an upper horizontal part and a vertical lower part. From the union of the horizontal parts of the two parietal bones results a central plate whose anterior part is triangular and concave. This is the only part of the parietals that is visible when the skull is viewed directly from the front. The posterior part that lies behind the line joining the bases of the horn cores of the frontal bones is more or less quadrilateral in outline, presenting a comparatively smooth and slightly convex outer surface which looks directly upward. The lower vertical part that forms part of the medial wall of the temporal fossa is slightly convex from the front backward, and it is not concave from above downward as in the case of the carabao and cow. Its anterior border is nearer to the frontal crest than in the carabao.

Frontal.—The frontal bone is relatively narrower transversely than in the carabao. Externally the nasofrontal part is more concave in front, but nearly flat behind. There is no indication of the frontal eminence at the junction of its posterior border and the parietal bone. The horn cores are relatively smaller, shorter, and less curved than in the carabao. They are more or less three sided and taper to a blunt point. They are directed almost straight backward, turning toward each other moderately at the points; they also run a little downward bringing the ends to lie in the line of the orbit. The supraorbital foramen is relatively smaller and is placed higher. The groove leading from it is narrower but deeper. The supraorbital process is weaker but relatively longer than in the carabao or cow. The orbital part as well as the temporal part of the bone is less concave and extensive.

Temporal.—The temporal bone of the timarau is characterized by the following features: The temporal crest is poorly developed, and the zygomatic process is not as strong as in the carabao. The external aspect of the part of the squamous temporal that concurs with the parietal in the formation of the medial wall of the temporal fossa is moderately convex, instead of being concave as in the carabao or cow. The postglynoid process is very poorly developed. The posterior process forms a distinct muscular eminence behind the external acoustic process. Aside from the difference in size, the muscular process, the bulla ossea and the acoustic process present no other features of interest.

BONES OF THE FACE

The bones of the face, aside from the difference in size, present only a few important special features as compared with those of the carabao.

Maxilla.—The facial tuberosity of the maxilla is only represented by a slightly elevated rough area, placed about an inch above the alveolus of the third premolar tooth; from it extends backward and upward an ill-defined ridge which gradually fades out and terminates at the junction of the maxilla and the malar bone. The infraorbital foramen is relatively small and is located just in front of the level of the alveolus for the first premolar tooth. The maxillary tuberosity is very poorly developed and very much compressed laterally; it bears a short blunt-pointed process that projects upward and backward. As in the carabao this bone does not form any defect in its nasal

wall for it directly articulates with the nasal bone, and the interval they form is completely occupied by the posterior extremity of the nasal process of the premaxilla. The anterior part of the palatine process is narrow and is deeply concave transversely. The maxillary foramen is slitlike and small.

Premaxilla.—The body of the premaxilla is relatively thin and small, otherwise it resembles that of the carabao; the foramen incisivum is represented by a notch. The palatine process is practically as long as in the carabao and its posterior end is overlapped by the anterior end of the vomer; it is deeply grooved in the nasal surface for the reception of the ventral edge of the vomer. The palatine fissure is narrow. The nasal process is well developed and more or less prismatic; its posterior end completely occupies the interval of the nasal and maxillary bones.

Palatine.—The palatine bone closely resembles that of the carabao.

Nasal.—The nasal bone, except in size, does not present many important differential features that will attract attention. The lower end of this bone is divided by a notch into an outer and an inner process; the latter is the smaller, instead of being the larger, as is the case in the carabao.

Lacrimal.—The bulla of the lacrimal bone is proportionately larger. In other respects this bone resembles that of the carabao.

Malar.—The facial part of the malar bone bears a less distinct ridge as compared with that of the carabao. This ridge is apparently the continuation of the ill-defined crest of the maxilla. The region behind the crest is less concave dorsoventrally. The upper extremity of the bone is bifurcate, the upper branch being relatively shorter and weaker than in that of the carabao or cow. The bone does not curve very much laterally.

Aside from the difference in size the pterygoid bone does not materially differ from the same bone in the carabao.

Vomer, hyoid, and turbinate.—The vomer, hyoid, and turbinate bones resemble those of the carabao practically in all respects.

Mandible.—The mandible likewise resembles very closely that of the carabao in general form. The outer aspect of the perpendicular part of the ramus, however, is comparatively smooth, presenting very few and less salient muscular ridges.

THE SKULL AS A WHOLE

The skull of the timarau resembles in most respects that of the carabao. The upper half of the frontal surface is relatively narrower than in the latter animal, and it presents a slightly depressed central area. The roof of the cranium is almost flat. There is no indication at all of the so-called median "frontal eminence." The supraorbital foramen is placed higher and the horn cores are more or less three-sided and comparatively smaller and shorter; they run almost straight backward and a little downward. The zygomatic arches and supraorbital processes do not curve outward as much as in the carabao.

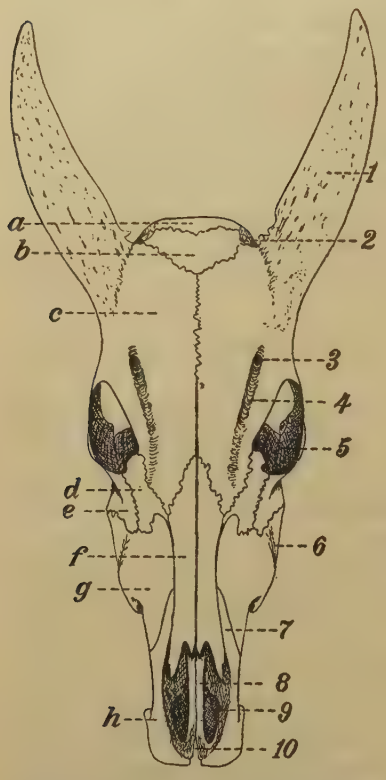

FIG. 2. Frontal view of the skull of the timarau. *a*, Fused interparietal and supraoccipital; *b*, fused dorsal or horizontal parts of the parietals; *c*, frontal bone; *d*, lacrimal; *e*, malar; *f*, nasal; *g*, maxilla; *h*, premaxilla; *1*, horn core (processus cornus); *2*, external parietal crest; *3*, supraorbital foramen; *4*, supraorbital groove; *5*, orbit; *6*, maxillary tuberosity; *7*, nasal process of premaxilla; *8*, palatine process of premaxilla; *9*, palatine fissure; *10*, palatine (notch) cleft.

The following are the most salient differential features of the lateral surface: The facial tuberosity is only represented by a slightly raised rough area, and the curved crest that extends from it is ill-defined and incomplete. The temporal fossa encroaches more on the posterior surface; it is relatively shallower than in the carabao and its medial wall is moderately convex from before backward. The external parietal crest, which limits the fossa behind, is better defined. At the junction of the anterior extremity of the body of the maxilla and the nasal process of the premaxilla is a thin triangular plate of bone projecting downward and outward.

The cranial part of the basal surface is relatively narrower than in the carabao, and the tubercles in front of the occipital condyles as well as the ventral tubercles at the junction of the occipital and sphenoid bones are rather poorly developed. The

posterior nares are completely divided medially by the vomer. The anterior palatine foramina are also found at the junction of the horizontal part of the palatine bone and the palatine process of the maxilla. The triangular plate of bone resulting from the union of the anterior extremity of the body of the maxilla and the nasal process of the premaxilla is also visible in this surface.

The posterior surface (nuchal surface) is distinctly divided by a better-developed nuchal crest into an upper and a lower area. The upper area is formed by the frontals, interparietals and supraoccipital; it is more or less quadrilateral in outline and less extensive than the lower one; it is smooth and slightly convex from side to side; and it is separated from the temporal fossa by the parietal crests. The area below the nuchal crest is rough and wide transversely below; the external occipital protuberance consists only of a small rough elevation flanked on either side by a depression. Extending from this elevation is a faint ridge that terminates below into a depression bounded on either side by a rounded muscular eminence formed at the junction of the squamous and lateral parts of the occipital bone. Other features of this surface resemble very closely those of the carabao.

The cranial cavity as well as the nasal cavity, aside from the difference in size, is practically the same as in the carabao. Mention may be made here that no attempt was made to open and study the paranasal sinuses because we did not feel justified in destroying the only mounted skeleton of the timarau in the College.

THE VERTEBRAL COLUMN

The number of bones observed in each region of the vertebral column of the timarau is indicated in the following formula, each region being denoted by its initial letter; C_7 T_{13} L_6 S_5 Cy_{15}. As to the number of bones, the sacral region of the vertebral column of this animal differs from that of the carabao, being made of only four segments or vertebræ, and in the case of the ox the difference lies in the coccygeal region, the number of coccygeal vertebrae in the latter animal varying from 18 to 20.

Cervical vertebræ.—Except in respect to size these bones resemble very closely those of the carabao. With the atlas and axis, however, the following points are noteworthy: The tuberosity of the dorsal arch of the atlas is relatively better developed than in the carabao, resembling very closely that of the ox.

The wings are relatively thinner and less horizontal, and the posterior border of the dorsal arch is deeply notched. The fossa atlantis is shallower. The spinous process of the axis is comparatively weaker and its free border is less tuberous. The intervertebral foramen is placed farther behind, and the foramen transversarium is relatively small. The transverse processes are directed downward, outward, and backward, instead of being horizontal as in the case of the carabao.

Thoracic vertebræ.—As compared with the same bones in the carabao, these vertebræ do not present any striking differential features, save that they are smaller and less voluminous and that the free ends of the spinous processes are less tuberculate. Besides, both the anterior and posterior edges of the spinous processes are straighter and more regular.

Lumbar vertebræ.—Aside from the difference in size these vertebræ do not materially differ from those of the carabao. The mammillary processes of these bones, however, are less prominent and not as tuberous as in the latter animal; and the transverse processes are relatively weaker and their edges are more regular.

Sacrum.—This bone is relatively longer but less voluminous than in the carabao; it is made of five segments or vertebræ as in the ox. It is less arched. The spinous processes are lower, and only those of the second, third, fourth, and fifth vertebræ are completely fused together. The lateral borders are not very thin, sharp, and irregular. The pelvic surface is less concave in both directions, and the central groove is hardly traceable.

Coccygeal vertebræ.—There are only fifteen coccygeal vertebræ. A complete arch is present in the first seven bones, which possess also transverse processes and distinct, though nonfunctional, anterior articular processes. The arches as well as the transverse and articular processes become more or less rudimentary as they are traced backward. It may be remarked here that the transverse processes of the first vertebra resemble very closely those of the last segment of the sacrum both in development and size, so that by casual observation it appears to be a component of the sacrum which has not fused.

THE THORAX

As in the carabao the ribs of the timarau number thirteen pairs—eight sternal and five asternals. They are proportionately shorter, narrower, but more strongly curved than in the

carabao. The necks are relatively shorter, and the facets of the tubercles are not deeply concave. The borders are more regular.

The sternum consists also of seven sternibræ and resembles that of the carabao in general form. It is, however, relatively shorter and placed less obliquely. The first sternebra is not so bent upward, and the thorax is more barrel-shaped than in the carabao or ox.

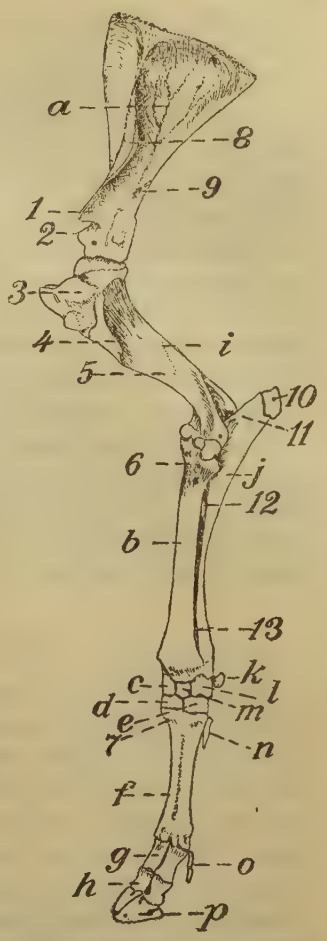

FIG. 3. Lateral aspect of the articulated bones of the thoracic limb of the timarau. *a*, Scapula; *b*, radius; *c*, radial carpal; *d*, fused second and third carpals; *e*, fourth carpal; *f*, large metacarpal; *g*, first phalanx; *h*, second phalanx; *i*, humerus; *j*, ulna; *k*, accessory carpal; *l*, ulnar carpal; *m*, intermediate carpal; *n*, small metacarpal; *o*, bones of the accessory digit; *p*, third phalanx; *1*, rudiment of acromion; *2*, tuber scapulae; *3*, lateral tuberosity of the humerus; *4*, deltoid tuberosity; *5*, musculospiral groove; *6*, radial tuberosity; *7*, metacarpal tuberosity; *8*, tuber spinæ; *9*, nutrient foramen of scapula; *10*, olecranon process; *11*, olecranon fossa; *12*, upper interosseous space; *13*, lower interosseous space.

THE BONES OF THE THORACIC LIMB

Scapula.—The scapula of the timarau resembles very closely that of the carabao in general form, but in size it is relatively smaller. The spinous process is more sinuous and the tuber spinæ is less tuberous and poorly developed. The acromion is hardly recognizable. The supraspinous and infraspinous fossæ are shallower and the anterior border is regular. The tuber scapulæ, as well as its coracoid process, is less pronounced.

Humerus.—As compared with the same bone in the carabao, the humerus of the timarau presents the following features that are worth noticing: It is shorter and less voluminous. The musculospiral groove is deeper; the deltoid tuberosity is more pronounced; the teres tuberosity is ill-defined; the curved line extending from the deltoid tuberosity to the neck is hardly distinguishable; and the nutrient foramen is located about the middle of the medial surface.

Radius and ulna.—Except in point of size and the poorly developed radial tuberosity, the radius and ulna are almost identical with those of

the carabao. The ulna is rather more slender and less curved in its length.

Carpals.—The carpus consists also of six carpal bones—four in the proximal row and two in the distal row. The bones are very much reduced in size, otherwise they are similar to those of the carabao.

Metacarpals.—As in the carabao, two bones are present in the metacarpus of the timarau, the large metacarpal bone formed by the consolidation of the third and the fourth and the lateral small metacarpal or the fifth metacarpal bone. The large metacarpal is relatively shorter, but it is not very much expanded in its distal part, as is the case in the carabao; its tuberosity (metacarpal tuberosity) is rather poorly developed.

Phalanges and sesamoids.—Aside from the difference in size, the phalanges and sesamoids of the digits—the fully developed third and fourth and the rudimentary second and fifth—correspond almost exactly in general forms and characters with those of the carabao.

THE BONES OF THE PELVIC LIMB

Os coxæ.—The os coxæ correspond almost exactly in general form to those of the carabao. The following differential points, however, are noteworthy: The crest of the ilium is almost straight; the gluteal line is very faint; the psoas tubercle is less pronounced; and the tuber coxæ are less tuberous and massive. The tuber ischii is likewise less massive, and the superior ischiatic spine has fewer and less-developed vertical lines laterally. The conjugate diameter of the anterior aperture or inlet of the pelvis is 16.5 centimeters, while the transverse diameter is 12.5 centimeters.

Femur.—The femur of the timarau differs only from that of the carabao in size, being relatively shorter and less voluminous, in addition to the presence of a rather deep supracondyloid fossa and less-developed supracondyloid crests.

Tibia.—The shaft of the tibia is less curved and the muscular lines (linea muscularis) on the posterior surface are fewer and less distinct. In other respects this bone resembles that of the carabao.

Patella and fibula.—The patella and the fibula are very much reduced in size, but in other features they correspond almost

exactly with those of the carabao.

Tarsals, metatarsals, phalanges, and sesamoids.—The tarsal and metatarsal bones as well as the phalanges and sesamoids of the pelvic limb are likewise almost identical with corresponding bones in the carabao; they present no striking features except their small size.

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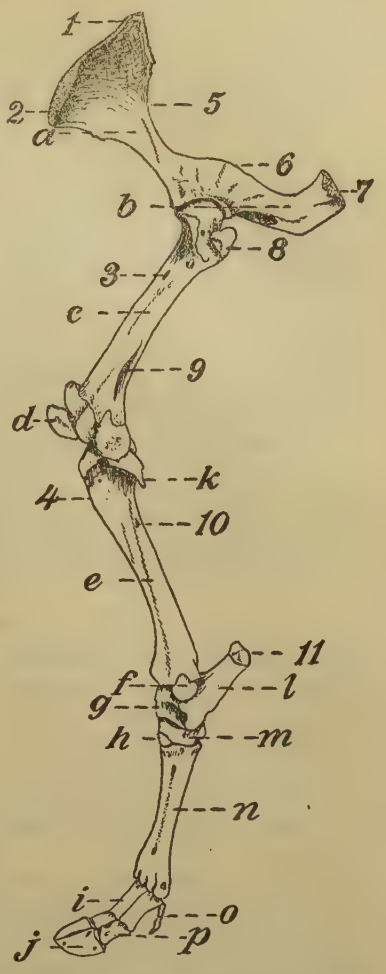

FIG. 4. Lateral aspect of the articulated bones of the pelvic limb of the timarau. *a*, Ilium; *b*, ischium; *c*, femur; *d*, patella; *e*, tibia, *f*, distal end of fibula (lateral malleolus); *g*, tibial tarsal; *h*, fused second and third tarsals; *i*, first phalanx; *j*, third phalanx; *k*, proximal part of fibula; *l*, fibular tarsal; *m*, fused central and fourth tarsals; *n*, large metatarsal; *o*, bones of the accessory digit; *p*, second phalanx; *1*, tuber sacrale; *2*, tuber coxæ; *3*, nutrient foramen of the femur; *4*, crest of tibia; *5*, greater sciatic notch; *6*, superior ischiatic spine; *7*, tuber ischii; *8*, trochanter major; *9*, supracondyloid fossa; *10*, nutrient foramen of tibia; *11*, tuber calcis.

ILLUSTRATIONS

PLATE 1

FIG. 1. A timarau near Bongabong River, Mindoro. (Photograph by E. A. Heise, 1921.)

2. Timarau *Bubalus mindorensis* Heude, from a living animal in Mehan Gardens, Manila. This species is restricted to Mindoro. (Photograph by Cortes.)

PLATE 2

Lateral view of the mounted skeleton of an adult timarau in the anatomical museum of the College of Veterinary Science, University of the Philippines (Photograph by the College of Agriculture.)

PLATE 3

Anterolateral view of the mounted skeleton of an adult timarau of the anatomical museum of the College of Veterinary Science, University of the Philippines. (Photograph by the College of Agriculture.)

TEXT FIGURES

FIG. 1. Lateral view of the skull of the timarau. *a*, Part of the frontal bone; *b*, lacrimal; *c*, malar; *d*, nasal; *e*, maxilla; *f*, premaxilla; *g*, temporal; *h*, occipital; *i*, hyoid; *j*, mandible. *1*, horn core; *2*, lacrimal fossa; *3*, infraorbital foramen; *4*, mental foramen; *5*, maxillary tuberosity; *6*, temporal fossa; *7*, coronoid process of the mandible; *8*, temporal crest; *9*, mastoid process; *10*, external acoustic meatus; *11*, paramastoid process; *12*, zygomatic arch; *13*, lacrimal bulla.

2. Frontal view of the skull of the timarau. *a*, Fused interparietal and supraoccipital; *b*, fused dorsal or horizontal parts of the parietals; *c*, frontal bone; *d*, lacrimal; *e*, malar; *f*, nasal; *g*, maxilla; *h*, premaxilla; *1*, horn core (processus cornus); *2*, external parietal crest; *3*, supraorbital foramen; *4*, supraorbital groove; *5*, orbit; *6*, maxillary tuberosity; *7*, nasal process of premaxilla; *8*, palatine process of premaxilla; *9*, palatine fissure; *10*, palatine (notch) cleft.

3. Lateral aspect of the articulated bones of the thoracic limb of the timarau. *a*, Scapula; *b*, radius; *c*, radial carpal; *d*, fused second and third carpals; *e*, fourth carpal; *f*, large metacarpal; *g*, first phalanx; *h*, second phalanx; *i*, humerus; *j*, ulna; *k*, accessory carpal; *l*, ulnar carpal; *m*, intermediate carpal; *n*, small metacarpal; *o*, bones of the accessory digit; *p*, third phalanx; *1*, rudiment of acromion; *2*, tuber scapulæ; *3*, lateral tuberosity of the humerus; *4*, deltoid tuberosity; *5*, musculospiral groove; *6*, radial tuberosity; *7*, metacarpal tuberosity; *8*, tuber spinæ; *9*, nutrient foramen of scapula; *10*, olecranon process; *11*, olecranon fossa; *12*, upper interosseous space; *13*, lower interosseous space.

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PLATE 1. TIMARAU, BUBALUS MINDORENSIS HEUDE.

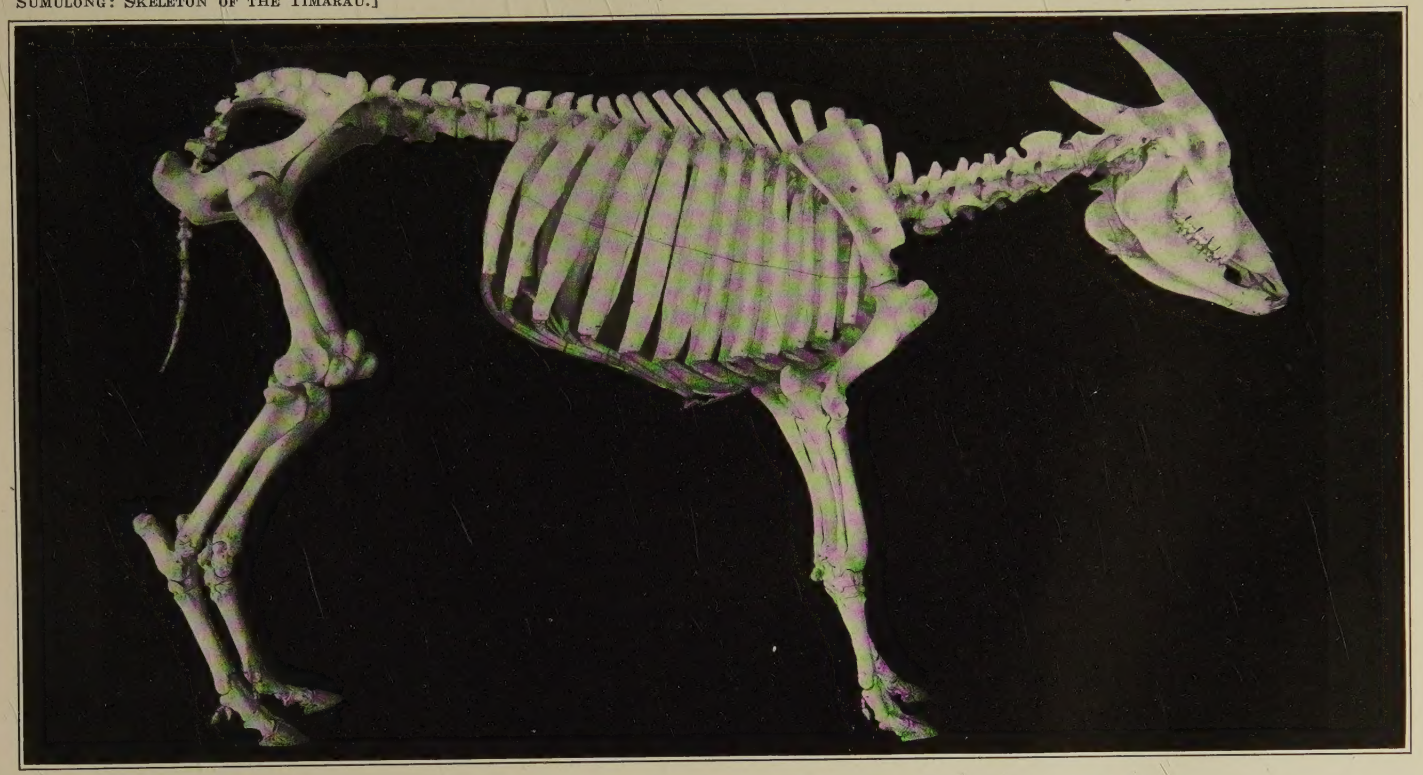

PLATE 2. LATERAL VIEW OF THE MOUNTED SKELETON OF AN ADULT TIMARAU.

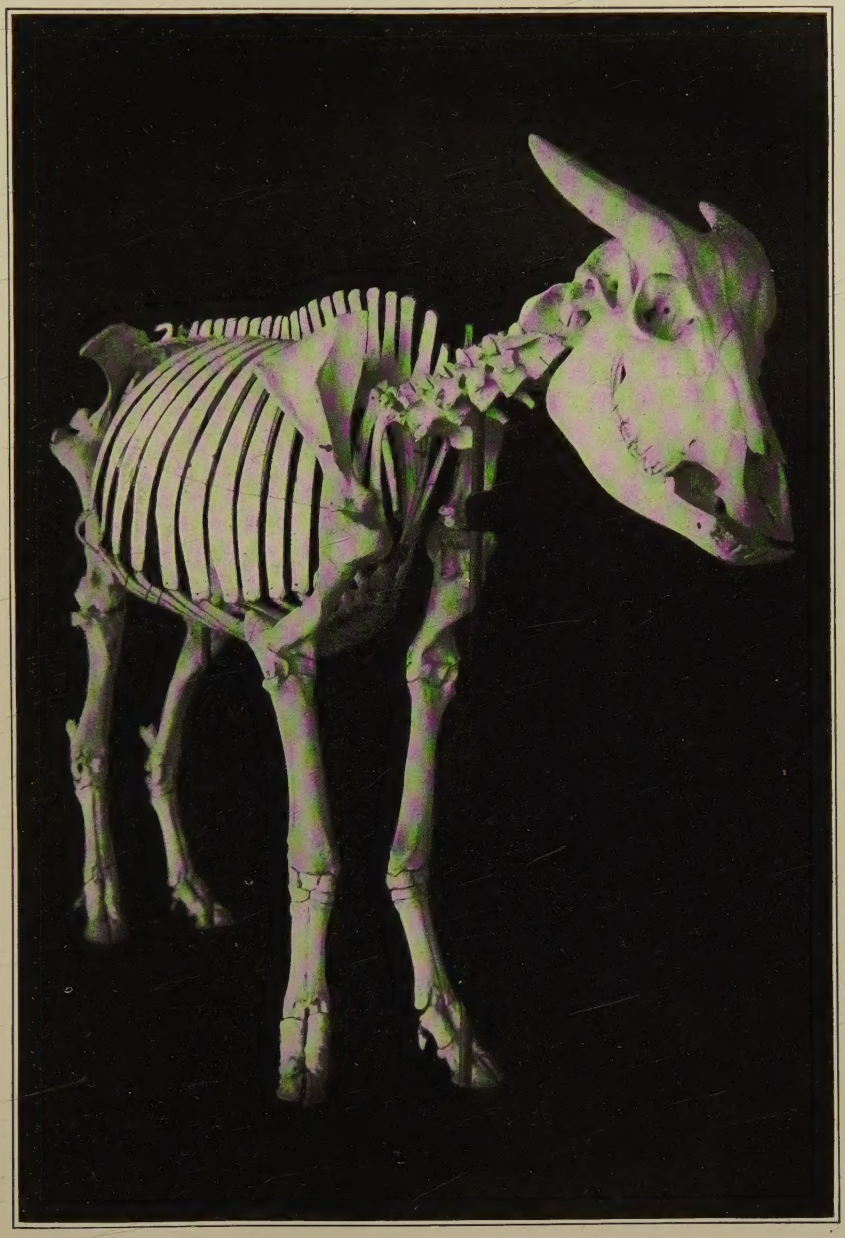

PLATE 3. ANTERO-LATERAL VIEW OF THE MOUNTED SKELETON OF AN ADULT TIMARAU IN THE ANATOMICAL MUSEUM OF THE COLLEGE OF VETERINARY SCIENCE, UNIVERSITY OF THE PHILIPPINES.